PHILCO SERVICE

WORLD-WIDE WITH THE ARMED FORCES

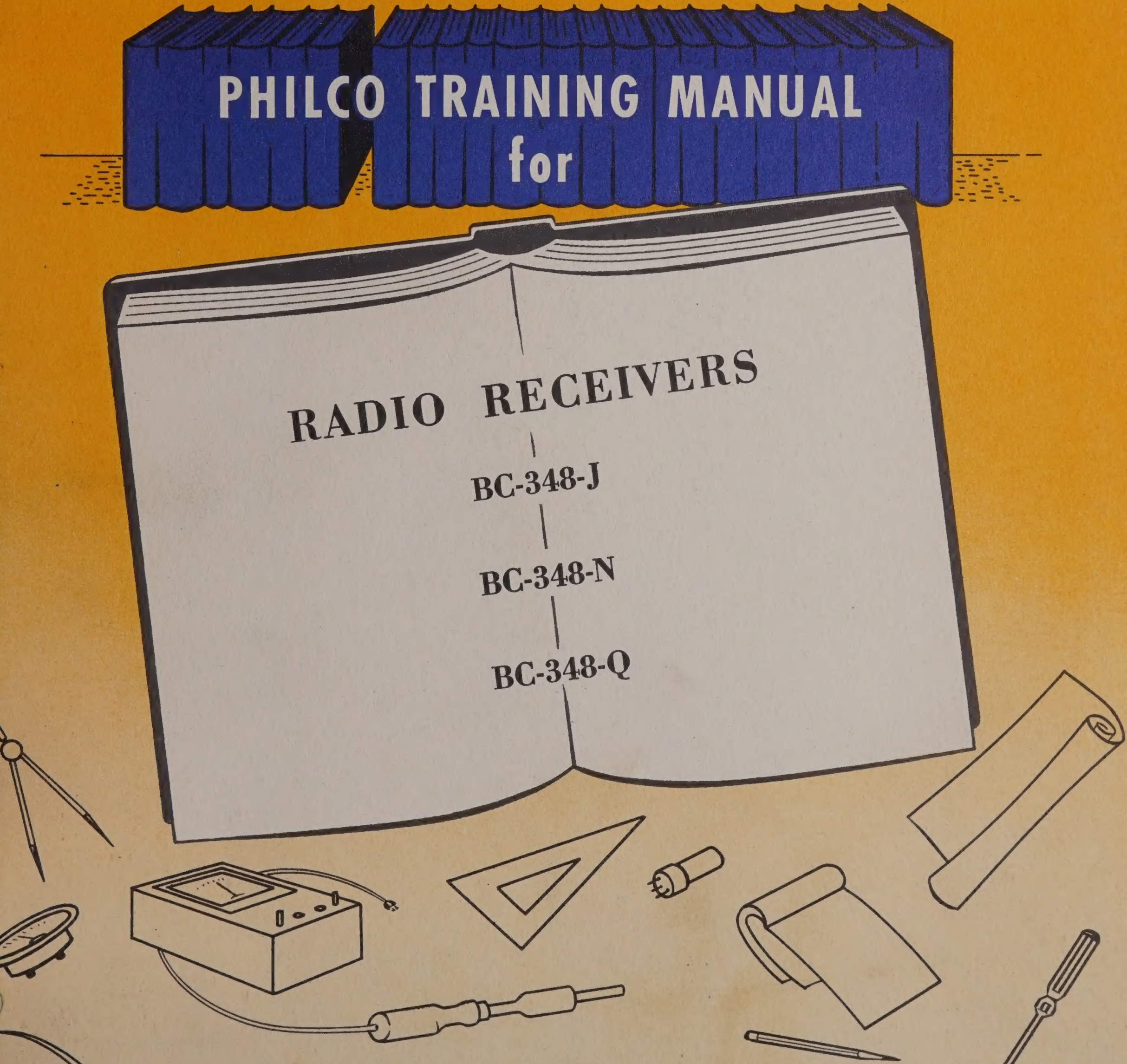
PHILCO TRAINING MANUAL for

RADIO RECEIVERS

BC-348-J

BC-348-N

BC-348-Q



"This document is for the information of the contractor's personnel. Should information contained herein conflict with technical orders, manuals, or other official publications of the U.S. Armed Forces, instructions in such publications will govern and no action by service activities on any information contained in this document is authorized."

COURSE OUTLINE

SUBJECT	*TIME ALLOTTED (HR.)*	*PAGE*
Lecture No. 1, Introductory Information	1/4	3
Lecture No. 2, General Information	1	4
Experiment No. 1, Physical Identification	1	7
Lecture No. 3, Functional Block Analysis	3/4	9
Experiment No. 2, Major Test Points	3/4	14
Lecture No. 4, Circuit Analysis of the 1st and 2nd R-F Stages	1	15
Experiment No. 3, 1st and 2nd R-F Stages	2	18
Lecture No. 5, Circuit Analysis of the 1st-Detector and Heterodyne-Oscillator Stages	1	20
Experiment No. 4, 1st-Detector and Heterodyne-Oscillator Stages	1 1/2	23
Lecture No. 6, Circuit Analysis of the 1st, 2nd, and 3rd I-F Stages	1 1/4	25
Experiment No. 5, 1st, 2nd, and 3rd I-F Stages	2 1/2	28
Lecture No. 7, Circuit Analysis of the Crystal-Filter Circuit	1/2	29
Review No. 1	3	31
Examination No. 1	2	31
Review of Examination No. 1	1	32
Lecture No. 8, Circuit Analysis of the 2nd-Detector Stage and A-V-C Circuit	3/4	33
Lecture No. 9, Circuit Analysis of the C-W Oscillator Stage	1/2	35
Experiment No. 6, 2nd Detector, A.V.C., and C-W Oscillator	1 1/2	38
Lecture No. 10, Circuit Analysis of the Audio-Amplifier Stage	1/2	39
Experiment No. 7, Audio-Amplifier Stage	1 1/2	41
Lecture No. 11, Circuit Analysis of the Power-Supply Circuit	1/2	42
Experiment No. 8. Power-Supply Circuit	1	45
Lecture No. 12, Alignment and Adjustment	1 1/2	46
Experiment No. 9, Alignment and Adjustment	3	50
Lecture No. 13, Trouble-Shooting	1 1/2	53
Experiment No. 10, Trouble-Shooting	2	54
Lecture No. 14, Preventive Maintenance	1/4	54
Experiment No. 11, Preventive Maintenance	1 1/2	55
Lecture No. 15, Special Information	1/2	56
Review No. 2	4	58
Final Review	2	58
Final Examination	5	58
Review of Final Examination	2	59
Total	49	

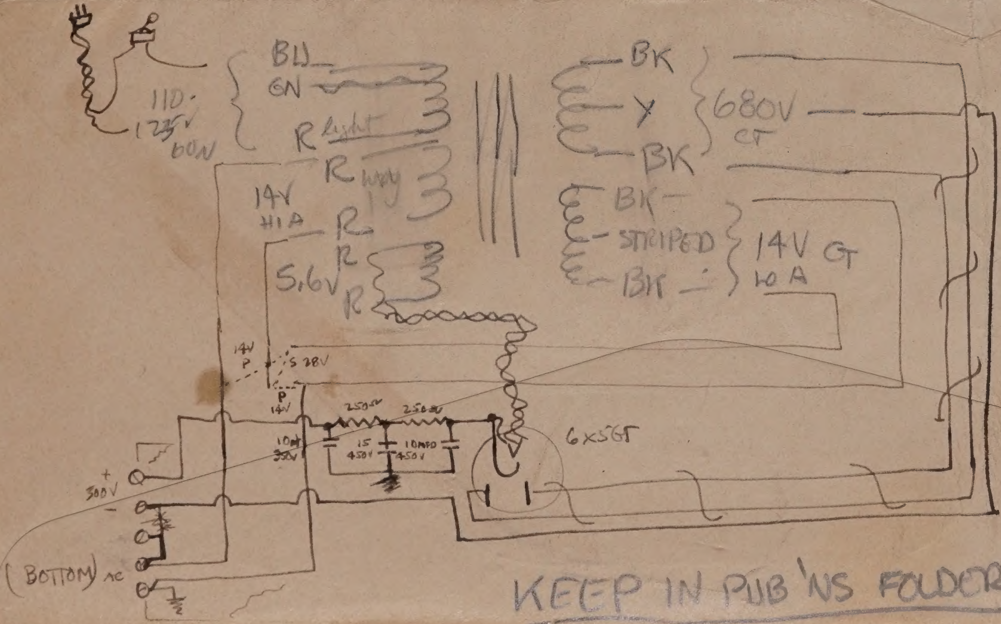
Copyright, 1949, Philco Corporation

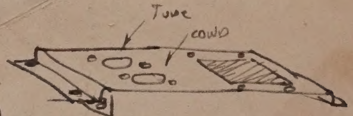
AFTER FIVE DAYS RETURN TO
Union Switch & Signal Co.
1789-1807 BRADDOCK AVE.
SWISSVALE P. O.
PITTSBURGH 18, PA.

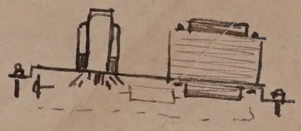
"Union" US&S CAB SIGNALS Expedite Traffic

SWISSVALE AUG 16'46 PA.
U.S. POSTAGE 03
P.B. METER 107382

For
APR-4
Rec'd


110-
125V
60N
BU
GN
R light
R way
14V
4.1 A
R
R
5.6V
R
BK
X
BK
680V
CT
BK
STRIPED
BK
14V CT
10 A
14V
P
S 28V
P
14V
250Ω
250Ω
10MF
350V
15
450V
10MFD
450V
6X5GT
+
300V
-
(BOTTOM) AC

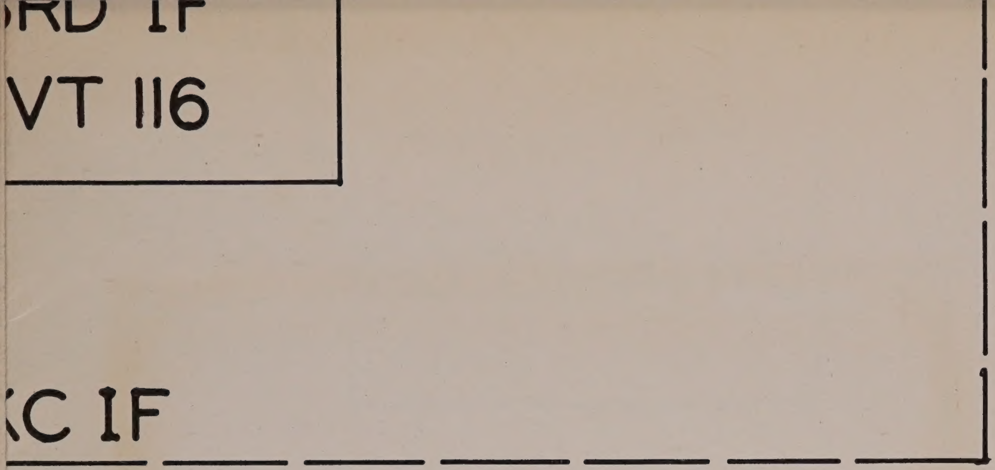




BC348 &
BC224
AC POWER SUPPLY?

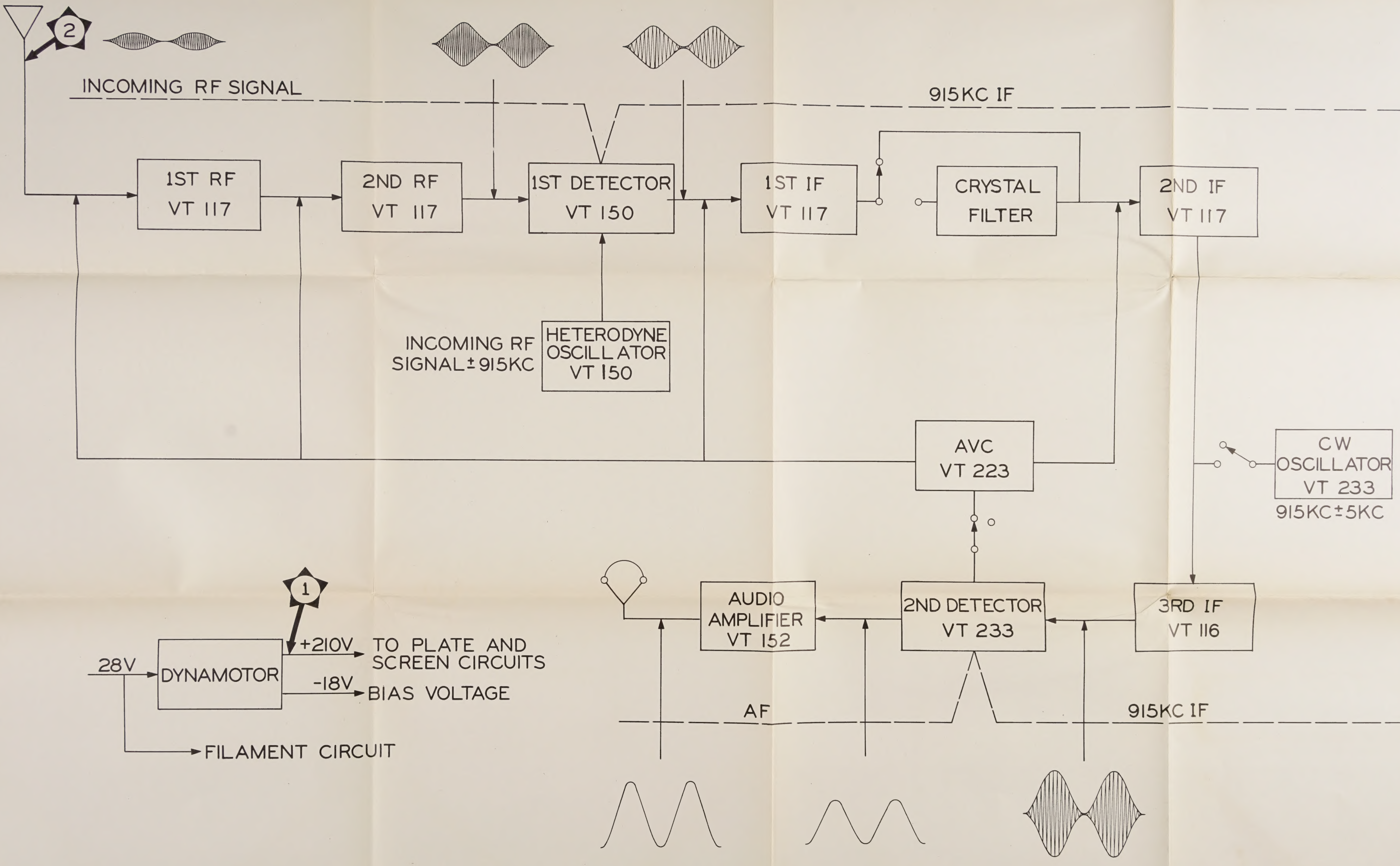
DEC 30 1946

KEEP IN PUB'NS FOLDER


RD IF
VT 116
C IF

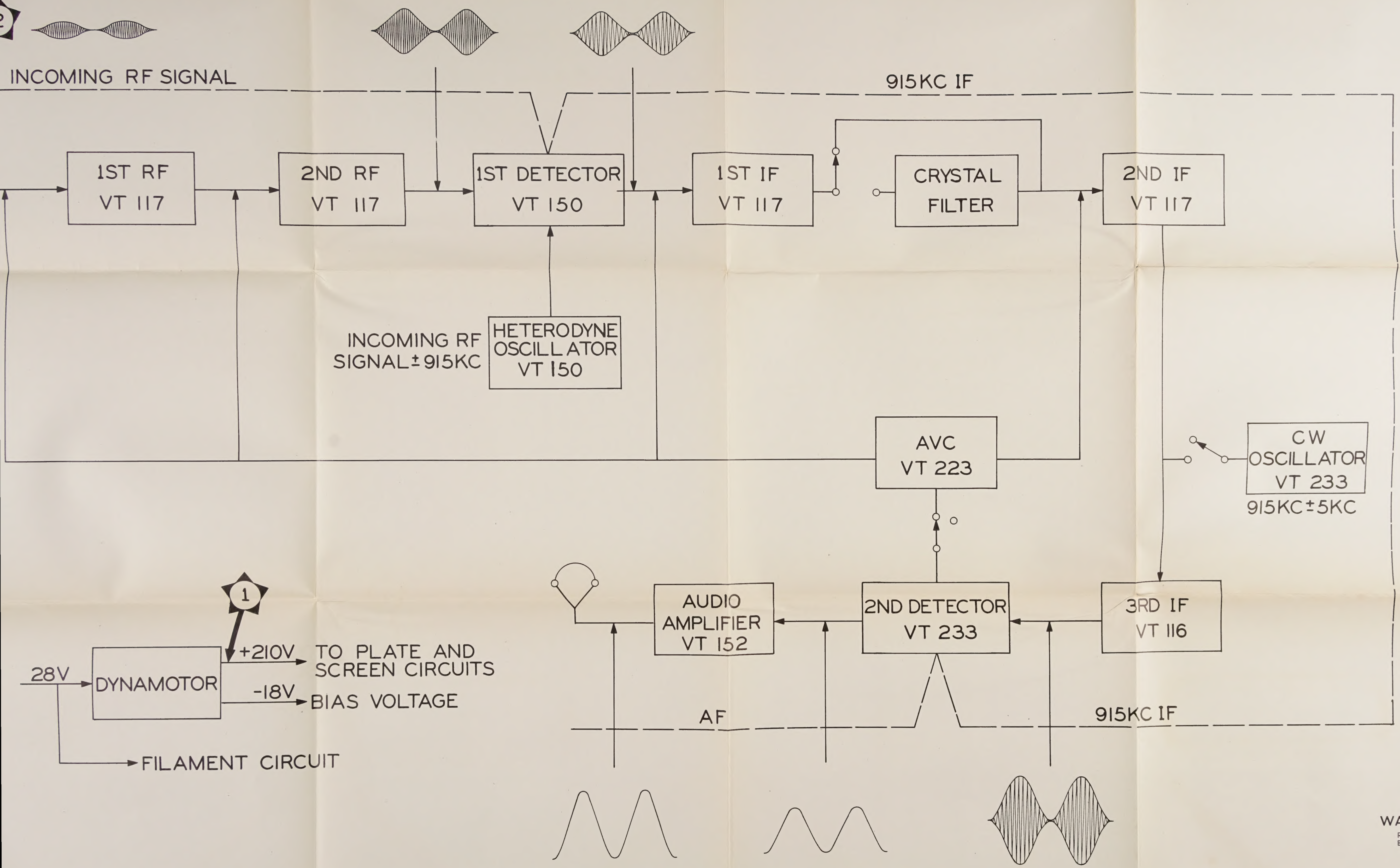
WALL CHART No. 1

Radio Receiver BC-348-J,
BC-348-N, or BC-348-Q,
Functional Block
Diagram.


②
INCOMING RF SIGNAL
915KC IF
1ST RF VT 117
2ND RF VT 117
1ST DETECTOR VT 150
1ST IF VT 117
CRYSTAL FILTER
2ND IF VT 117
INCOMING RF SIGNAL ± 915KC
HETERODYNE OSCILLATOR VT 150
AVC VT 223
CW OSCILLATOR VT 233
915KC ± 5KC
①
AUDIO AMPLIFIER VT 152
2ND DETECTOR VT 233
3RD IF VT 116
28V
DYNAMOTOR
+210V
TO PLATE AND SCREEN CIRCUITS
-18V
BIAS VOLTAGE
FILAMENT CIRCUIT
AF
915KC IF

WALL C

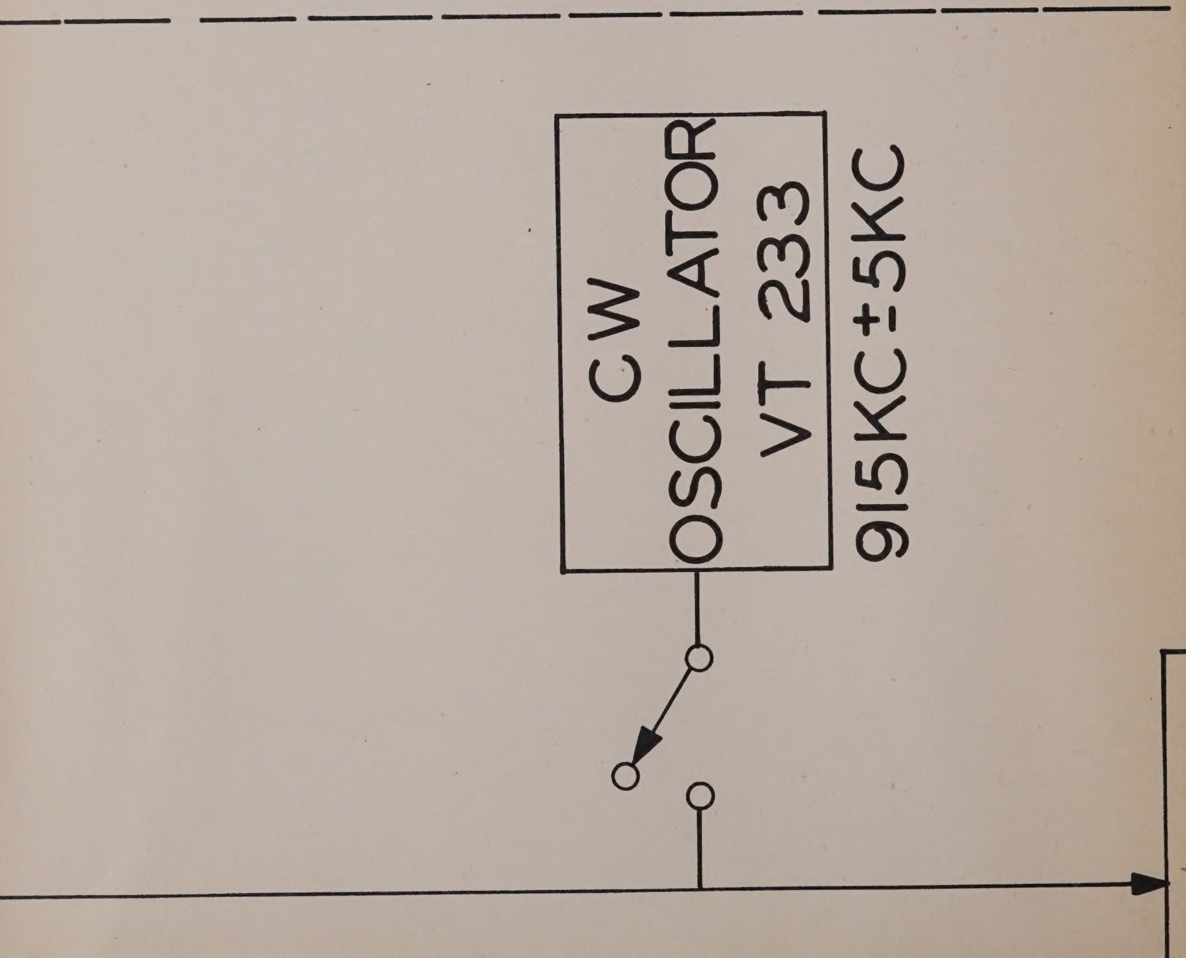
Radio Rec
BC-348-N
Func
D

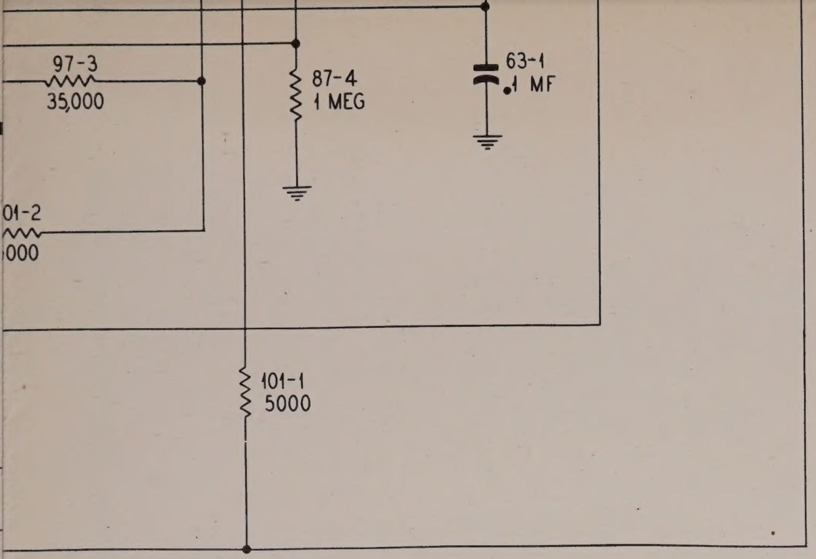

INCOMING RF SIGNAL
915KC IF
1ST RF
VT 117
2ND RF
VT 117
1ST DETECTOR
VT 150
1ST IF
VT 117
CRYSTAL
FILTER
2ND IF
VT 117
INCOMING RF
SIGNAL ± 915KC
HETERODYNE
OSCILLATOR
VT 150
AVC
VT 223
CW
OSCILLATOR
VT 233
915KC ± 5KC
1
AUDIO
AMPLIFIER
VT 152
2ND DETECTOR
VT 233
3RD IF
VT 116
28V
DYNAMOTOR
+210V
TO PLATE AND
SCREEN CIRCUITS
-18V
BIAS VOLTAGE
AF
915KC IF
FILAMENT CIRCUIT

WORLD WIDE
PHILCO
SERVICE

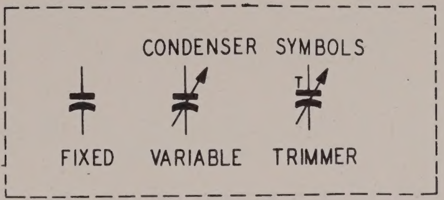
WALL CHART No. 1

Radio Receiver BC-348-J,
BC-348-N, or BC-348-Q,
Functional Block
Diagram.


CW
OSCILLATOR
VT 233
915KC±5KC


97-3
35,000
87-4
1 MEG
63-1
.1 MF
01-2
000
101-1
5000

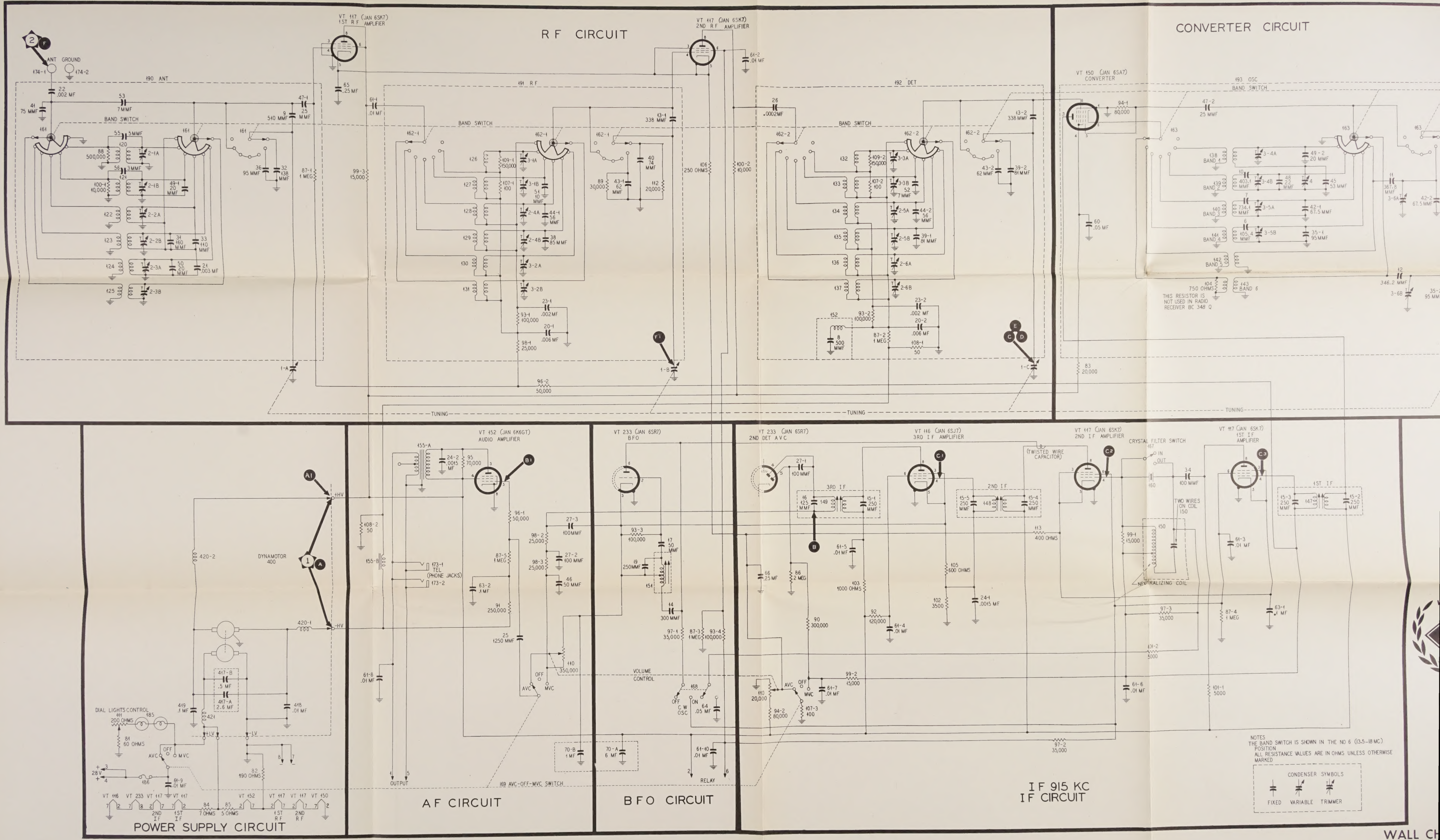
NOTES
THE BAND SWITCH IS SHOWN IN THE NO 6 (13.5–18 MC) POSITION
ALL RESISTANCE VALUES ARE IN OHMS UNLESS OTHERWISE MARKED


CONDENSER SYMBOLS
T
FIXED
VARIABLE
TRIMMER

WORLD WIDE
PHILCO
SERVICE

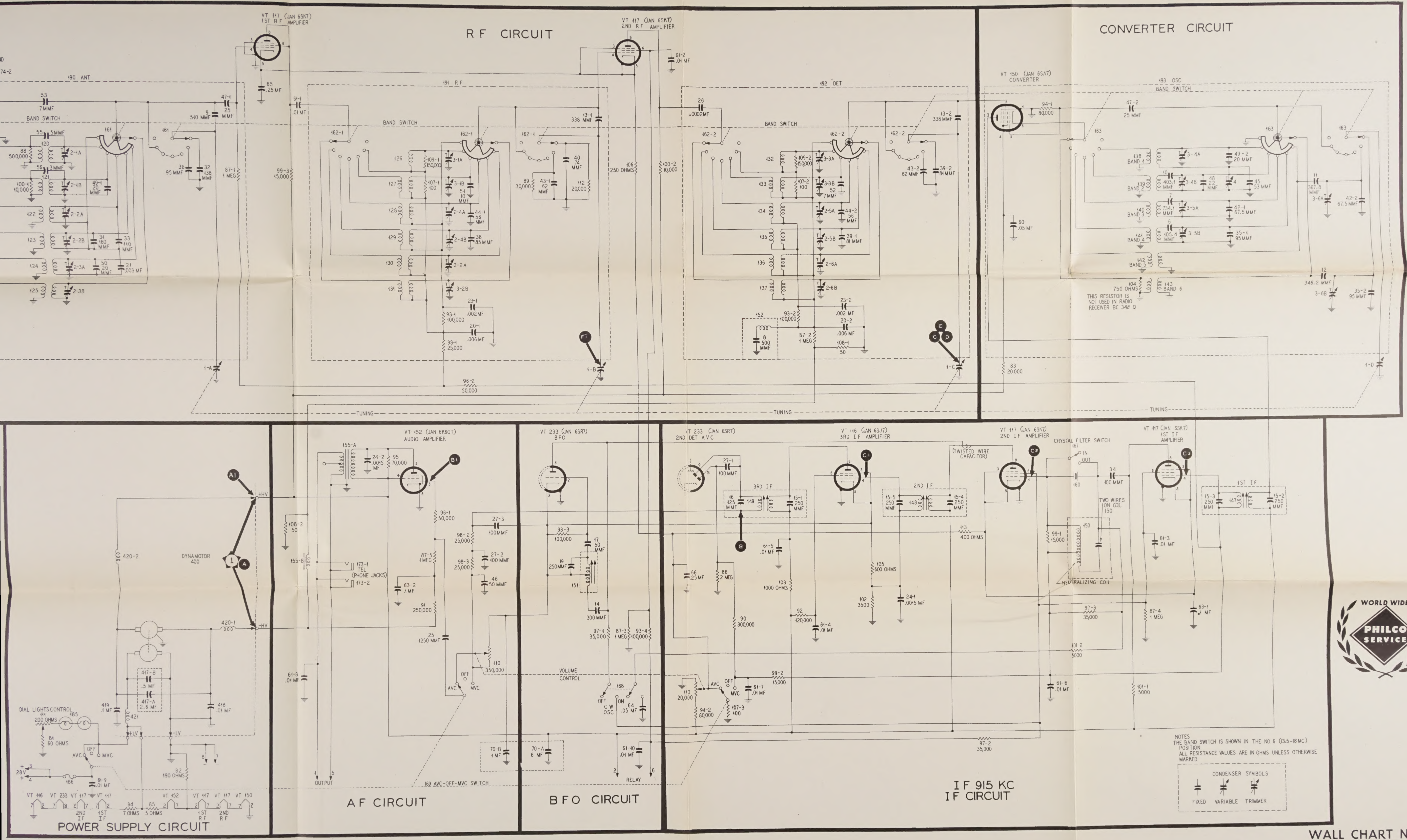
WALL CHART No. 2

Radio Receiver BC-348-J, BC-348-N,
or BC-348-Q, Schematic Diagram,
Showing Test Points.


R F CIRCUIT
CONVERTER CIRCUIT
VT 117 (JAN 6SK7) 1ST R F AMPLIFIER
VT 117 (JAN 6SK7) 2ND R F AMPLIFIER
VT 150 (JAN 6SA7) CONVERTER
ANT GROUND
190 ANT
191 R F
192 DET
193 OSC
BAND SWITCH
TUNING
THIS RESISTOR IS NOT USED IN RADIO RECEIVER BC 348 Q
POWER SUPPLY CIRCUIT
DYNAMOTOR 400
DIAL LIGHTS CONTROL
AVC OFF MVC
28 V
AF CIRCUIT
VT 152 (JAN 6K6GT) AUDIO AMPLIFIER
TEL (PHONE JACKS)
OUTPUT
169 AVC-OFF-MVC SWITCH
BFO CIRCUIT
VT 233 (JAN 6SR7) B F O
VOLUME CONTROL
C W OSC
RELAY
I F 915 KC
I F CIRCUIT
VT 233 (JAN 6SR7) 2ND DET A V C
VT 116 (JAN 6SJ7) 3RD I F AMPLIFIER
VT 117 (JAN 6SK7) 2ND I F AMPLIFIER
VT 117 (JAN 6SK7) 1ST I F AMPLIFIER
3RD I F
2ND I F
1ST I F
CRYSTAL FILTER SWITCH
IN
OUT
TWISTED WIRE CAPACITOR
TWO WIRES ON COIL 150
NEUTRALIZING COIL
CONDENSER SYMBOLS
FIXED
VARIABLE
TRIMMER

NOTES
THE BAND SWITCH IS SHOWN IN THE NO 6 (13.5–18 MC) POSITION
ALL RESISTANCE VALUES ARE IN OHMS UNLESS OTHERWISE MARKED

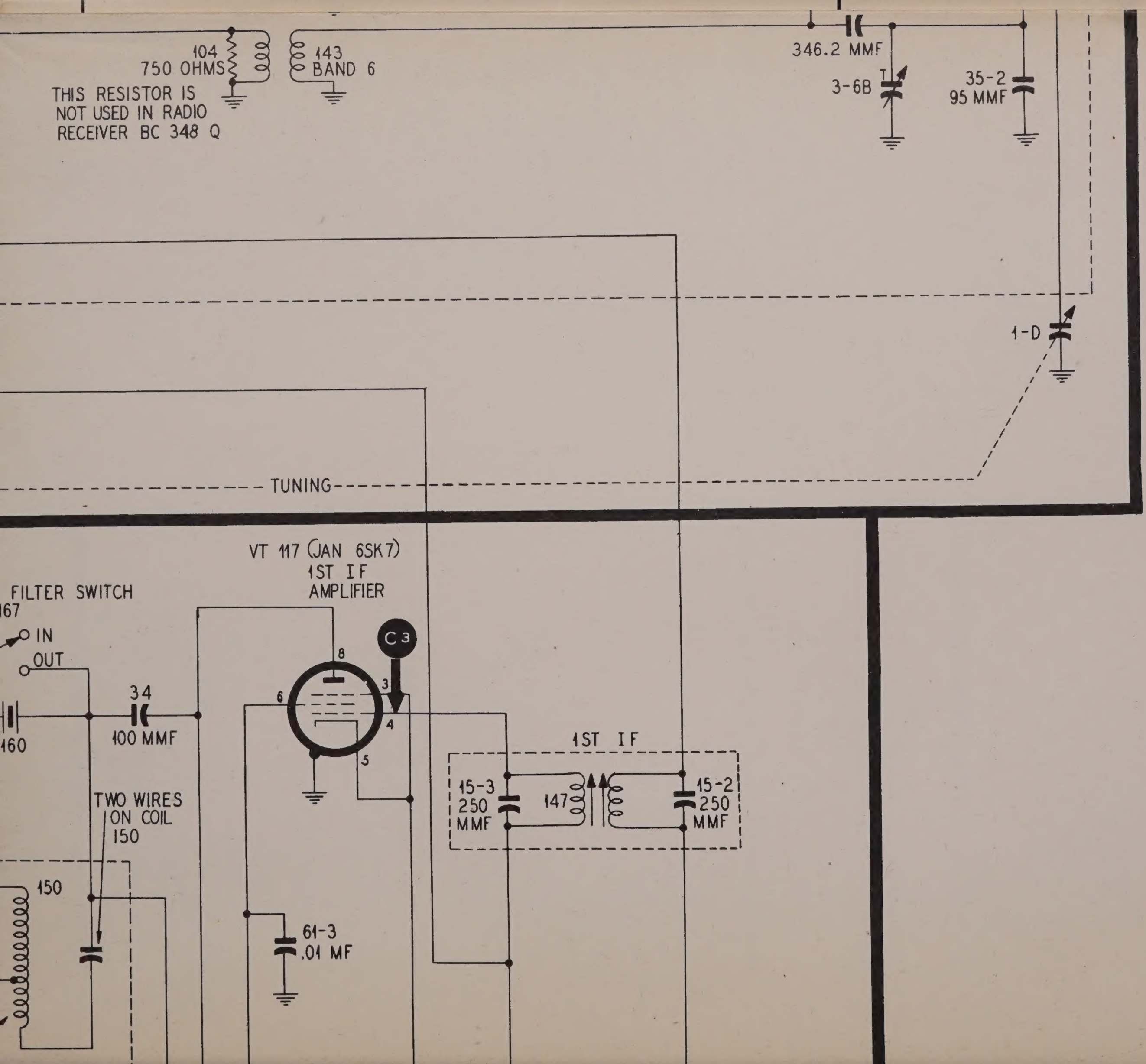
WALL CH
Radio Receiver
or BC-348-Q,
Showing


R F CIRCUIT
CONVERTER CIRCUIT
VT 117 (JAN 6SK7) 1ST R F AMPLIFIER
VT 117 (JAN 6SK7) 2ND R F AMPLIFIER
VT 150 (JAN 6SA7) CONVERTER
190 ANT
191 R F
192 DET
193 OSC
BAND SWITCH
TUNING
THIS RESISTOR IS NOT USED IN RADIO RECEIVER BC 348 Q
POWER SUPPLY CIRCUIT
DYNAMOTOR 400
DIAL LIGHTS CONTROL
+HV
-HV
+LV
-LV
28 V
AF CIRCUIT
VT 152 (JAN 6K6GT) AUDIO AMPLIFIER
TEL (PHONE JACKS)
OUTPUT
169 AVC-OFF-MVC SWITCH
VOLUME CONTROL
BFO CIRCUIT
VT 233 (JAN 6SR7) BFO
C.W OSC
RELAY
VT 233 (JAN 6SR7) 2ND DET AVC
VT 116 (JAN 6SJ7) 3RD I F AMPLIFIER
VT 117 (JAN 6SK7) 2ND I F AMPLIFIER
VT 117 (JAN 6SK7) 1ST I F AMPLIFIER
CRYSTAL FILTER SWITCH
(TWISTED WIRE CAPACITOR)
TWO WIRES ON COIL
NEUTRALIZING COIL
3RD I F
2ND I F
1ST I F
I F 915 KC
I F CIRCUIT
A1
A
B1
B
C1
C2
C3
C
D
E
F1
CONDENSER SYMBOLS
FIXED
VARIABLE
TRIMMER

NOTES
THE BAND SWITCH IS SHOWN IN THE NO 6 (13.5–18 MC) POSITION
ALL RESISTANCE VALUES ARE IN OHMS UNLESS OTHERWISE MARKED

WORLD WIDE
PHILCO SERVICE

WALL CHART No. 2
Radio Receiver BC-348-J, BC-348-N, or BC-348-Q, Schematic Diagram, Showing Test Points.


104
750 OHMS
THIS RESISTOR IS NOT USED IN RADIO RECEIVER BC 348 Q
143
BAND 6
346.2 MMF
3-6B
T
35-2
95 MMF
1-D
TUNING
VT 117 (JAN 6SK7)
1ST IF
AMPLIFIER
C 3
8
3
6
4
5
FILTER SWITCH
167
IN
OUT
34
100 MMF
160
1ST IF
15-3
250
MMF
147
15-2
250
MMF
TWO WIRES ON COIL 150
150
61-3
.01 MF

ANSWER AND TROUBLE-SHOOTING SUPPLEMENTS FOR RADIO RECEIVERS BC-348-J, BC-348-N, AND BC-348-Q

ANSWER SUPPLEMENT

EXAMINATION No. 1, PART I

1. The functional block diagram may be checked with the drawing in figure 5.
2. A mounting is used which has four shock-absorbers between the base and upper plates.
3. The input voltage required by the dynamotor is 28 volts, d.c. The positive high voltage supplied by the dynamotor is 210 volts, d.c.; the negative voltage is 18 volts, d.c.
4. The frequency range is 200 to 500 kc., and 1.5 to 18 mc.; this range is covered by six bands.
5. It connects the receiver to: (a) the 28-volt d-c power source; (b) the aircraft interphone system; (c) the transmitter relay.
6. The AVC-OFF-MVC switch. In the OFF position no power is supplied to the receiver. In the AVC position the receiver is turned on and the volume level selected by the INCREASE VOL. control is automatically maintained. In the MVC position the receiver is on, but the volume must be manually controlled.
7. The ganged tuning capacitors and the dial scale.
8. The cabinet is fastened to the chassis by means of two thumbscrew rods; the cabinet is fastened to the mounting by snap-slides.
9. When an incoming signal is not clear due to heavy interference, the improved selectivity provided by the crystal circuit is very helpful.
10. The ganged wafer switches, which select the appropriate components in the r-f, 1st-detector, and heterodyne-oscillator stages.
11. The C.W. OSC. switch and the BEAT FREQ. control. The C.W. OSC. switch turns on and off the c-w oscillator, which aids in producing audible signals during c-w reception. The BEAT FREQ. control varies the frequency of the c-w oscillator, and thus varies the tone of the audio output.
12. To select the desired signal and amplify it.
13. If there are no voice transmissions at that frequency, only background noise and, possibly, key clicks or other keying noises, will be heard; the c-w signal will not be heard.
14. At two headphone jacks on the front panel, and at terminals 1 and 5 of the connector plug.
15. To maintain automatically the volume of the audio signal at the level selected by the operator. If the signal coupled to the a-v-c diode from the 2nd detector increases in amplitude, the a-v-c circuit applies a negative voltage to the grids of the 1st and 2nd r-f and the 1st and 2nd i-f tubes, thus reducing the audio signal to its original level. When the input signal decreases, an opposite action takes place and the audio level is maintained.
16. Major test point ① checks the operation of the power-supply circuit. It is located at the positive and negative high-voltage terminals of the dynamotor. Major test point ② checks the overall operation of the receiver. It is located at the antenna post.
17. The capacitance in the selected tuned circuits varies, so that the frequency to which the circuits are tuned is varied. In this way the circuit can be continuously tuned throughout the entire band.
18. 2nd i-f stage.
19. 1165 kc.
20. In order to neutralize or balance out the undesired signals which are by-passed around the crystal by the crystal-holder capacitance.

EXAMINATION No. 1, PART II

1. c. 1st r-f.
2. d. Plate voltage of the 1st r-f tube drops to zero.
3. a. No headphone indication on band 5 operation.
4. c. Zero voltage reading between terminal 4 of VT-150 and ground.
5. c. C2 .
6. b. No improvement in selectivity when the CRYSTAL switch is turned to IN.
7. c. Shorted capacitor 63-1.
8. b. Ungrounded side of capacitor 1-C.
9. b. Make voltage and resistance measurements between the socket terminals of VT-116 and ground.
10. a. Shorted resistor 106.

FINAL EXAMINATION, PART I

1. 1st and 2nd r-f stages and 1st and 2nd i-f stages.
2. 915 kc.
3. Band 2: 2415—4415 kc.; band 6: 12,585—17,085 kc.
4. No.
5. The i-f filter trap.
6. The neutralizing capacitor is adjusted when the crystal circuit becomes unbalanced. The neutralizing capacitor consists of two wires and two lugs extending from the neutralizing coil.
7. Zero.
8. 1st and 2nd r-f, 1st-detector, and heterodyne-oscillator stages.
9. In aligning an i-f transformer the iron cores around which the coils are wound are adjusted. In aligning a tuned circuit in an r-f stage a trimmer capacitor is adjusted.
10. Feedback for the heterodyne oscillator is secured by means of a cathode coil coupled to the grid coil. Feedback for the c-w oscillator is secured from the plate circuit by means of an autotransformer which is coupled between the plate circuit and grid circuit.
11. In order to filter out the i-f and a-f components of the a-v-c voltage, thus providing a relatively

steady amount of voltage which varies only with the slow variations produced by the increasing and fading of the carrier signal.

12. The dynamotor bearings should be lubricated after 500 hours of service. The bearings can be reached by removing the dynamotor from the receiver chassis. When the dust covers at each end of the dynamotor are removed, the retaining plates are exposed. When the retaining plates and their associated washers are removed, the bearings are accessible for lubrication.

13. Tracking is the condition in which the first four stages of the receiver are adjusted in such a way that the 1st and 2nd r-f stages and 1st-detector stages can be simultaneously tuned to the same frequency, and that the frequency difference between these stages and the heterodyne oscillator is constant (915 kc.) at all settings of the TUNING control. Tracking is achieved through proper alignment of the stages concerned by adjusting the trimmer capacitors in the tuned circuits for maximum output.

14. With the C.W. OSC. switch in the OFF position, rotation of the BEAT FREQ. control produces no effect on the audio output, since the c-w oscillator stage is inoperative. With the switch in the ON position, rotation of the BEAT FREQ. control results in a varying pitch of the c-w signal in the headphones.

15. It is used in calibrating the tuning dial with the ganged tuning capacitors.

16. To detect the signal fed to it from the 3rd i-f stage, filter out the i-f component, and pass on to the audio stage only the audio component of the signal.

17. Because the circuit in which the trimmer capacitor is located is then tuned to the aligning frequency, resulting in maximum gain in that stage.

18. 2nd r-f stage and 1st and 2nd i-f stages.

19. 1st and 2nd r-f stages and 1st and 2nd i-f stages.

20. The high end of the band is used in aligning the band 6 circuits. The high and low ends of the band are used in aligning the band 1 circuits.

FINAL EXAMINATION, PART II

1. b. 350,000 ohms.
2. d. Shorted capacitor 61-5.
3. c. Open resistor 101-1.
4. a. Complete equipment failure.
5. d. C-w oscillator.
6. c. Shorted resistor 86.
7. c. C1 .
8. d. Shorted resistor 84.
9. b. Open resistor 92.
10. c. No c-w reception.

TROUBLE-SHOOTING SUPPLEMENT

EXPERIMENT No. 3

1. Remove the 1st r-f tube from the socket and insulate pin 5 by wrapping it with scotch tape, gummed paper, or similar material, to simulate a defective tube. Replace the tube.

2. Locate the six external terminals on the front of the shielded ANT. unit. Remove the 1st r-f tube and connect a jumper lead of small-diameter wire between the lowest terminal (when viewed from above) and the second terminal from the top, in the left-hand row. This wire will ground the tie-point between tuning capacitor 1-A and capacitor 9, and will simulate a shorted condition of the tuning capacitor and capacitors 32 and 33. Replace the tube.

EXPERIMENT No. 4

1. Locate the external terminals on the front of the shielded OSC. unit. Connect a 20,000-ohm, 1-watt resistor between the lowest terminal in the left-hand row and ground. This resistor will simulate a leaky screen by-pass capacitor (60) in the 1st-detector, hetrodyne-oscillator stage.

2. Remove VT-150 from the socket. Insulate pin 7 of the tube, to simulate an open filament. Replace the tube.

EXPERIMENT No. 5

1. Disconnect the connector plug and insulate prong 6 of the male section. This simulates a bad connection and removes the screen voltage from the 1st and 2nd i-f tubes. Reconnect the plug.

2. Remove the 2nd and 3rd i-f tubes from their sockets. Insulate pin 4 of each, to simulate defective i-f tubes. Replace the tubes.

EXPERIMENT No. 6

1. Connect a jumper lead from socket terminal 5 of VT-233 (a-v-c diode) to ground (the ground lug located between socket terminals 5 and 6 may be used). This jumper will simulate a shorted a-v-c resistor (resistor 86).

2. While viewing the bottom of the chassis from above, locate the AVC-OFF-MVC wafer switch (169) on the rear of the front panel, just behind the AVC-OFF-MVC control. Connect a jumper lead between the fourth and fifth lugs, counting in a clockwise direction from the highest point of the switch. This jumper will ground the a-v-c circuit through resistor 107-3 in all positions of the switch, and will simulate a defective AVC-OFF-MVC switch.

EXPERIMENT No. 7

1. Insulate the tips of both phone jacks, to simulate defective phone jacks; the phone-jack tips are located on the underside of the chassis in the right-front corner.

2. Connect a jumper lead from terminal 2 of the output transformer (155-A) to ground, to simulate a short in the audio-output filter capacitor, 61-8.

EXPERIMENT No. 8

1. Locate the five screws on the dynamotor terminal strip. Loosen the center screw, remove the spade terminal and conceal it behind the end plate. Tighten the screw. Disconnecting this terminal simulates an open in the filament-supply circuit.

2. Remove the fuse from the fuse-holder and replace it with a defective fuse.

EXPERIMENT No. 11

1. Place any of the troubles described in this supplement in the equipment.

FINAL EXAMINATION

Part III. Select any six of the troubles described in this supplement and place them, one at a time, in the equipment.

LECTURE No. 1

INTRODUCTORY INFORMATION

Radio Receivers BC-348-J, BC-348-N, and BC-348-Q are essentially alike, with minor variations in the value of a few circuit components; therefore, this course will consider Radio Receiver BC-348-J, and variations in the other receivers will be noted at appropriate times.

Radio Receiver BC-348-J is intended primarily for use in military aircraft for reception of signals from transmitters in other aircraft, on the ground, or in surface vessels (see figure 1).

Aircraft receivers are operated under many different conditions, which require them to possess a high degree of versatility and ruggedness. Radio Receiver BC-348-J fulfills these requirements; that is, it can be operated over a wide range of frequencies with little loss of time when changing frequencies, it is sturdily and compactly built, and it is shock-mounted to reduce vibrations. A dynamotor contained within the receiver cabinet provides the required power for operation. The receiver does not require an elaborate type of antenna. The effects of wide variations in temperature, which are encountered in changing altitude while flying, are compensated for in the design of certain circuits. Internal receiver noise is kept at a constant level over all bands by means of a flat-gain characteristic in the circuit design.

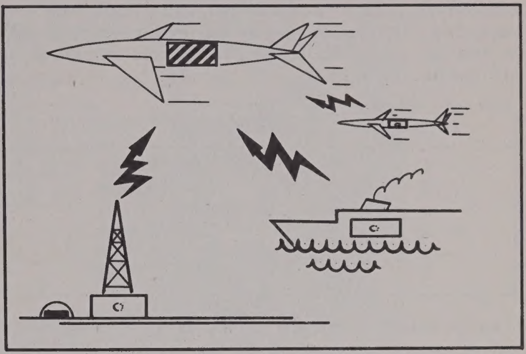


Figure 1. Application of Radio Receiver BC-348-J

LESSON PLAN No. 1

TIME ALLOTTED: ¼ HR.

SUBJECT

Introductory information.

OBJECTIVE

To provide an over-all picture of Radio Receivers BC-348-J, BC-348-N, and BC-348-Q.

INTRODUCTION

Radio Receivers BC-348-J, BC-348-N, and BC-348-Q are widely used in military aircraft because of their versatility and ruggedness.

SUBJECT MATERIAL

1. Radio Receivers BC-348-J, BC-348-N, and BC-348-Q are essentially alike, with a few variations in circuit components.

2. This course will consider Radio Receiver BC-348-J. Variations in the other receivers will be noted at appropriate times.

3. Receiver primarily intended for use in military aircraft.

4. Draw figure 1 on blackboard.

5. Receives signals from transmitters in other aircraft, on the ground, or in surface vessels.

6. Developed to operate under many different conditions which require versatility and ruggedness.

7. Can be operated over wide range of frequencies with little loss of time when changing frequencies.

8. Sturdy, compact, and shock-mounted to reduce vibrations.

9. Dynamotor in receiver cabinet provides necessary power.

10. Elaborate antenna not necessary.

11. Temperature variations compensated for in circuit design.

12. Internal receiver noise kept constant by circuit design.

CONCLUSIONS

Radio Receiver BC-348-J is designed for use under the great variety of conditions encountered in aircraft operation. It is dependable and versatile, and is widely used in military aircraft.

ORAL QUIZ

1. For what use is Radio Receiver BC-348-J intended?

2. What other equipment is similar in design to Radio Receiver BC-348-J?

3. For what type of operation is Radio Receiver BC-348-J used, and why is it suitable for this use?

4. Where is the dynamotor located?

LECTURE No. 2

GENERAL DESCRIPTION

Radio Receiver BC-348-J is an eight-tube superheterodyne, which is capable of voice, tone, and c-w reception. It operates in the frequency range of 200 to 500 kc. and 1.5 to 18 mc., and covers this range in six bands, as follows:

BAND	FREQUENCY RANGE
1	200— 500 kc.
2	1.5— 3.5 mc.
3	3.5— 6.0 mc.
4	6.0— 9.5 mc.
5	9.5—13.5 mc.
6	13.5—18.0 mc.

The power consumption of the receiver is 60 watts (if no power is supplied to the aircraft interphone system or similar auxiliary equipment through the output plug).

The over-all dimensions of the receiver, complete with mounting, are: 18″ long, 10½″ deep and 9½″ high. The total weight of the receiver, with mounting, is 38 pounds.

Radio Receiver BC-348-J consists of the following physical units:

Official Nomenclature	*Functional Title*
Radio Receiver BC-348-J	Receiver
Dynamotor DM-28-J (in receiver cabinet	Power supply
Mounting FT-154-J	Receiver mounting
Plug PL-P103 or	Connector plug (straight fitting)
Plug PL-Q103	Connector plug (right-angle fitting)

Radio Receiver BC-348-N consists of the following physical units:

Official Nomenclature	*Functional Title*
Radio Receiver BC-348-N	Receiver
Dynamotor DM-28-N (in receiver cabinet)	Power supply
Mounting FT-154-Q	Receiver mounting
Plug PL-P103 or	Connector plug (straight fitting)
Plug PL-Q103	Connector plug (right-angle fitting)

Radio Receiver BC-348-Q consists of the following physical units:

Official Nomenclature	*Functional Title*
Radio Receiver BC-348-Q	Receiver
Dynamotor DM-28-Q (in receiver cabinet)	Power supply
Mounting FT-154-AA	Receiver mounting
Plug PL-P103 or	Connector plug (straight fitting)
Plug PL-Q103	Connector plug (right-angle fitting)

The dynamotors, mountings, and plugs for the three receivers are identical. The dynamotors and mountings bear different numbers only because they are associated with the three different types of receivers.

Each receiver contains the following:

1. Two radio-frequency amplifiers, which select and amplify the desired signal.
2. The 1st detector, which mixes the incoming signal with the output of the heterodyne oscillator to produce an intermediate-frequency signal.
3. The heterodyne (local) oscillator, which creates a signal to be mixed with the incoming signal.
4. Three intermediate-frequency amplifiers, which amplify the output of the 1st detector.
5. The crystal filter, which increases the selectivity of the receiver by narrowing its band-pass.
6. The c-w oscillator (b.f.o.), which produces a signal to beat with the intermediate frequency so that c-w signals are made audible.
7. The 2nd detector, which detects the modulated signal and provides an audio signal for the audio amplifier.
8. The automatic volume control, which keeps the audio output at a uniform level.
9. The audio amplifier, which amplifies the audio signal and provides the output for the headset.
10. The dynamotor, which operates on 28 volts, d.c., and provides the high-voltage for the receiver. (Refer to figure 2 for the physical location of tubes, transformers and shielded units.)

The receiver cabinet is aluminum, of spot-welded construction, and has a black wrinkle finish. An opening is provided at the rear for the power connector plug. The cabinet is 18″ long, 8-15/16″ deep, and 8-5/8″ high. The chassis is an aluminum casting with end plates, which have cutouts to facilitate servicing of parts. The end plates, which have certain parts mounted on them, serve as runners for the chassis when it is placed in or removed from the cabinet. To remove the chassis from the cabinet, loosen the two thumbscrew rods, which pass through the front panel, and then pull the chassis out, using the two handles just above the thumbscrew rods on the front panel.

Mounting FT-154-J consists of a metal base, upon which four shock absorbers are mounted, and a second metal plate which is bolted to the top of the shock absorbers. A female power receptacle is mounted on the upper metal plate to accommodate the male power plug on the rear of the receiver. The upper metal plate is fastened to the cabinet by means of snapslides. When the receiver is being mounted, push both snapslides toward the center of the cabinet. Lift the receiver onto the mounting so that the rear studs on the bottom of the cabinet are in the groove on the mounting plate. Push the cabinet toward the rear of the mounting and at the same time lower the front of the cabinet. The studs will drop into the holes provided for them in the mounting. Push the receiver still farther backwards until it will go no far-

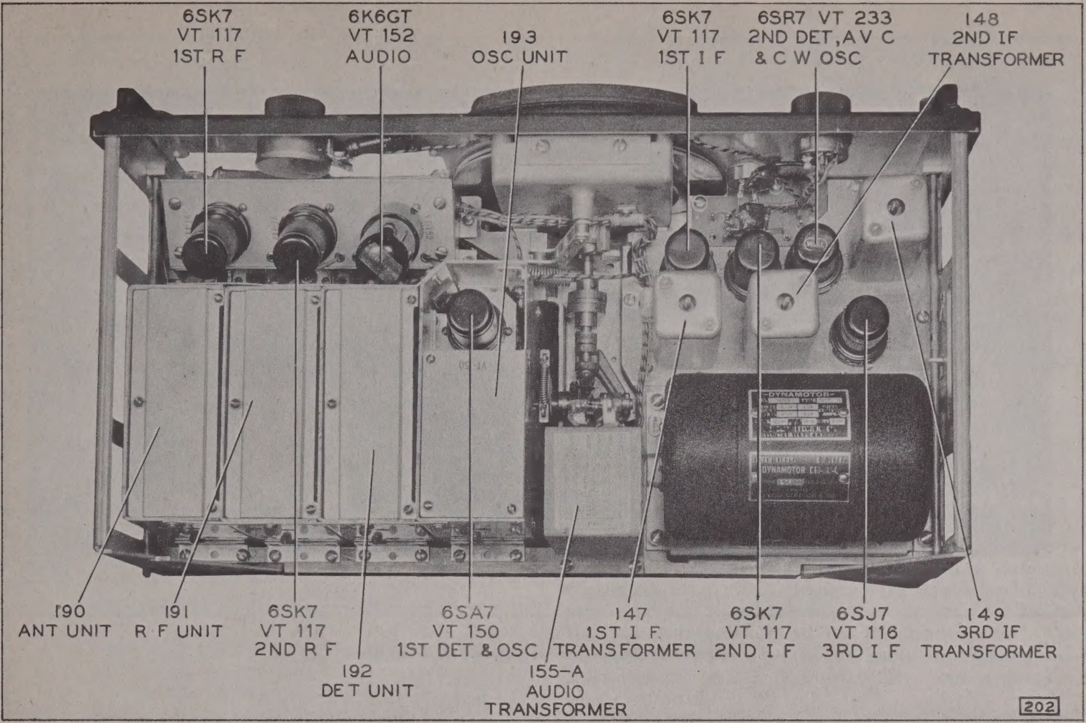

6SK7
VT 117
1ST R F
6K6GT
VT 152
AUDIO
193
OSC UNIT
6SK7
VT 117
1ST I F
6SR7 VT 233
2ND DET, AV C
& C W OSC
148
2ND IF
TRANSFORMER
190
ANT UNIT
191
R F UNIT
6SK7
VT 117
2ND R F
192
DET UNIT
6SA7
VT 150
1ST DET & OSC
155-A
AUDIO
TRANSFORMER
147
1ST I F
TRANSFORMER
6SK7
VT 117
2ND I F
6SJ7
VT 116
3RD I F
149
3RD IF
TRANSFORMER
202

Figure 2. Radio Receiver BC-348-J, Top View

ther. Push the snapslides on the front of the cabinet over the studs on the mounting plate, thus locking the receiver to the mounting. Insert safety wire through the holes in the snapslides.

When the receiver is installed in an aircraft, the metal mounting base should be securely fastened to a sturdy shelf or table which is easily accessible to the operator and which is located as near as possible to the antenna lead-in insulator. Sufficient clearance should be available on all sides of the cabinet, to allow free action of the shock absorbers. The entire mounting is 18″ long, 8½″ deep, and 1⅜″ high.

The front panel of the receiver, which is attached to the chassis, contains all of the controls necessary for operation. Starting at the left-hand end of the panel, the following jacks, controls, and binding posts will be found (see figure 3):

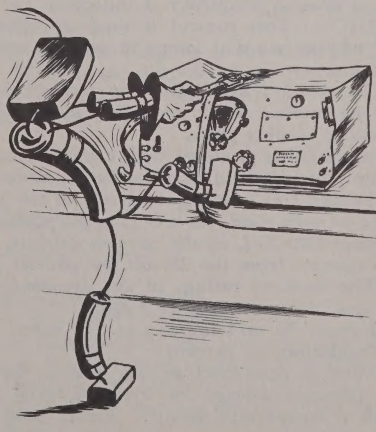
TEL.—Two audio output jacks, with snap covers, for headphone connections.

AVC-OFF-MVC—Three position wafer switch, which provides a means of turning on the set and selecting the type of volume control desired. When the switch is in the AVC position, the selected volume level is maintained automatically. In the MVC position, the volume must be controlled manually.

INCREASE VOL.—In MVC operation, this control is used to adjust the sensitivity of the receiver so that the desired audio level is provided. When AVC operation is employed, this control is set to the position which provides the desired audio level and the a-v-c circuit maintains the audio at that level.

C.W. OSC., OFF-ON—The control is used to turn on the c-w oscillator for the reception of continuous-wave (c-w) signals, and to turn it off for the reception of modulated signals.

CRYSTAL, OUT-IN—When an incoming signal is not clear due to heavy interference, and greater selectivity is desired, a sharply tuned crystal may be inserted into the i-f circuit by turning this switch to the IN position.



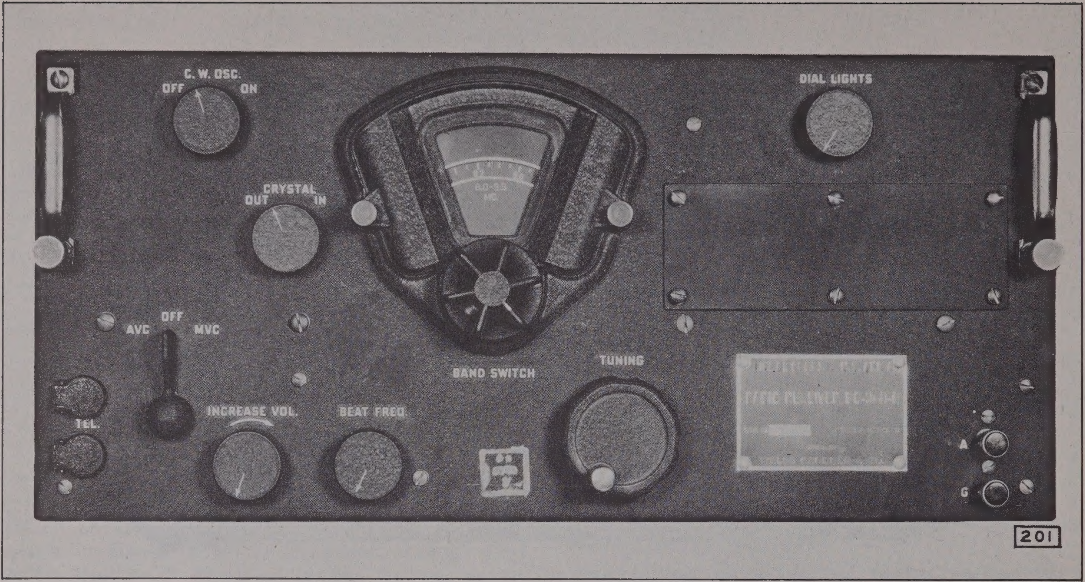


Figure 3. Radio Receiver BC-348-J, Front View

BEAT FREQ.—This control is used to adjust the frequency of the c-w oscillator, to obtain an audio tone of the desired pitch when receiving c-w signals.

BAND Switch—This switch is used to select the desired frequency band. It operates a dial mask containing a window through which the dial scale for the appropriate band can be seen. It also operates four ganged six-position wafer switches in the antenna, r-f, 1st detector, and heterodyne-oscillator stages, which simultaneously select the proper circuit components for each frequency band.

TUNING—This control is used to tune through the selected frequency band. It simultaneously operates ganged tuning capacitors in the r-f, 1st detector, and heterodyne-oscillator stages, and it moves the dial scale so that the selected frequency is indicated.

DIAL LIGHTS—This control is used to adjust the brilliance of the two dial lamps to suit the needs of the operator.

ANTENNA AND GROUND—The receiver is connected to the antenna and to ground by means of these spring-locking binding posts.

The front panel is provided with a small removable metal plate which is held in place by six screws. An opening behind this cover gives access to the underside of the r-f tube shelf, for servicing purposes.

Dynamotor DM-28-J, in the receiver cabinet, is designed to operate from the 28-volt d-c aircraft power supply. The nominal ratings of the dynamotor are:

Input: 1.3 amperes at 27.9 volts
Output: 70 milliamperes at 224 volts
Regulation: 12 percent

The 28 volts is connected to the receiver by Plug PL-P103 (straight fitting) or Plug PL-Q103 (same plug with a right-angle fitting). Either plug is an eight-contact flat-bladed connector plug which is inserted into the power-plug receptacle mounted by screws on the rear of the receiver mounting. Terminals 3, 4, 7, and 8 of the plug (see figure 4) are used to connect the set to the aircraft power supply. Terminals 1 and 5 carry the audio output to the interphone system, if so desired. If the receiver is used with a transmitter, terminals 2 and 6 connect the receiver to the transmitter relay. If the receiver is used without a transmitter, terminals 2 and 6 must be connected together to make the receiver operate. Note that, between terminals 2 and 5, there is available a maximum of 20 milliamperes at approximately 200 volts, which can be used to operate external equipment, if necessary. All leads to the receiver should be carefully measured and cut to the correct length, inserted through the fitting on the bottom of the connector plug, and soldered to the correct terminals.

LESSON PLAN No. 2

TIME ALLOTTED: 1 HR.

SUBJECT

General description.

OBJECTIVE

To describe Radio Receiver BC-348-J.

INTRODUCTION

Radio Receiver BC-348-J is an eight-tube superheterodyne, which is capable of voice, tone, and continuous-wave (c-w) reception in the frequency ranges of 200 to 500 kc. and 1.5 to 18 mc.

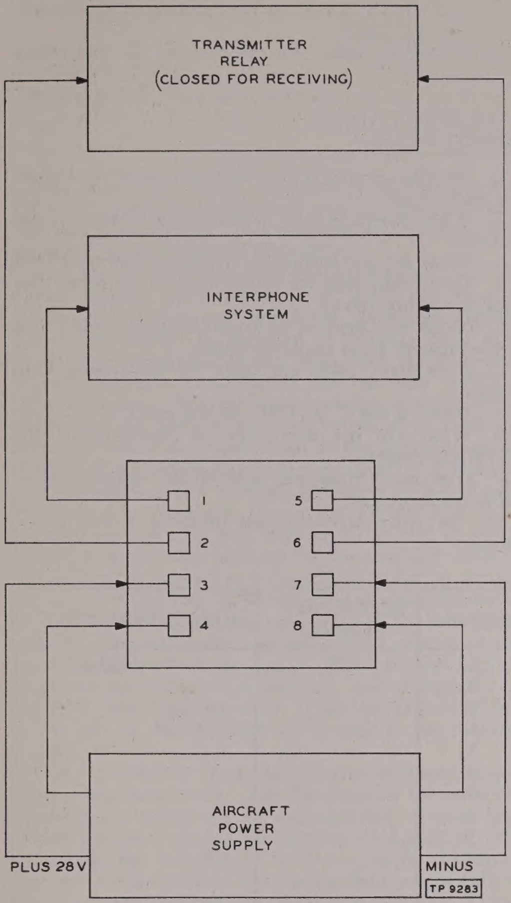


Figure 4. Connections for Plug PL-P103 or PL-Q103

SUBJECT MATERIAL

1. Frequency range on each band.
2. Power consumption.
3. Place receiver in view of students.
4. Over-all dimensions and weight of receiver, with mounting.
5. Explain official nomenclature and functional titles of physical units of Radio Receiver BC-348-J.
6. Explain that the nomenclature of dynamotors and mountings for Radio Receivers BC-348-N and BC-348-Q are different, even though these units are identical with those used for Radio Receiver BC-348-J.
7. Explain the purpose of the major circuits in the receiver and point out the locations of tubes, transformers, and shielded units.
8. Explain the construction and give the dimensions of the cabinet.
9. Explain the construction of the chassis and the method of removing it from the cabinet.
10. Explain the mounting and installation details and the method of mounting the receiver.
11. Locate and explain the purpose of each front-panel control.
12. Give the nominal ratings of the dynamotor and state the source of the 28-volt d-c power.
13. Draw figure 4 on the blackboard.
14. Explain the use of Plugs PL-P103 and PL-Q103.

CONCLUSIONS

Radio Receiver BC-348-J contains its own dynamotor in the receiver cabinet, and requires only one connector plug. It is designed for operation in the low, medium, and high-frequency bands. All operating controls are located on the front panel. The receiver has a number of desirable operational features, which include a crystal filter and a beat-frequency control.

ORAL QUIZ

1. What is the frequency range of Radio Receiver BC-348-J?
2. What is the total weight of the receiver, with mounting?
3. By what means is the chassis fastened to the cabinet?
4. What voltage is required by the dynamotor and where is it taken from?
5. What is the rated output of the dynamotor?
6. What is the function of the connector plug at the rear of the receiver?
7. What are the three functions of the AVC-OFF-MVC switch?
8. When should the CRYSTAL control be switched to the IN position?
9. What is the function of the C.W. OSC. control?
10. What is the purpose of the BAND SWITCH?
11. What occurs when the TUNING control is rotated?

EXPERIMENT No. 1

TIME ALLOTTED: 1 HR.

SUBJECT

Physical identification.

OBJECTIVE

To become familiar with the physical characteristics of Radio Receiver BC-348-J.

EQUIPMENT REQUIRED

Radio Receiver BC-348-J, complete with Mounting FT-154-J, Plug PL-P103 or PL-Q103, and headphones. Radio Receiver BC-348-N or BC-348-Q may be used, if necessary, since they are similar to the BC-348-J.

INSTRUCTIONS

Make certain that the power source is disconnected. Do not remove any components without the instructor's permission. Be especially careful of wire connections and tubes.

PROCEDURE

1. Remove the receiver from the mounting, using the following procedure:

a. Pull the snapslides on the front of the cabinet away from the studs on the mounting plate.

b. Make certain that the thumbscrew rods which hold the chassis to the cabinet are tight.

c. Pull the receiver cabinet forward while lifting, in order to disengage the studs on the bottom of the receiver from the holes in the mounting plate.

2. Replace the receiver on the mounting, using the following procedure:

a. Push both snapslides toward the center of the cabinet.

b. Lift the receiver onto the mounting so that the rear studs on the bottom of the cabinet are in the groove on the mounting plate.

c. Push the cabinet toward the rear of the mounting and, at the same time, lower the front of the cabinet. The studs will drop into the holes provided for them in the mounting.

d. Push the receiver still farther backwards until it will go no farther. Push the snapslides, on the front of the cabinet, over the studs on the mounting plate, thus locking the receiver to the cabinet.

3. Draw a front view of the receiver, showing the locations of controls, binding posts, headphone jacks, dial, etc. Indicate the functional title and reference symbol of each.

4. Remove the chassis from the cabinet, using the following procedure:

a. Loosen the two thumbscrews on the front panel.

b. Pull the chassis away from the cabinet, using the two handles on the front panel.

5. Using the following drawing, locate on the top side of the chassis the numbered items, giving their functional title and reference symbol in the chart provided.

6. Replace the chassis in the cabinet, using the following procedure:

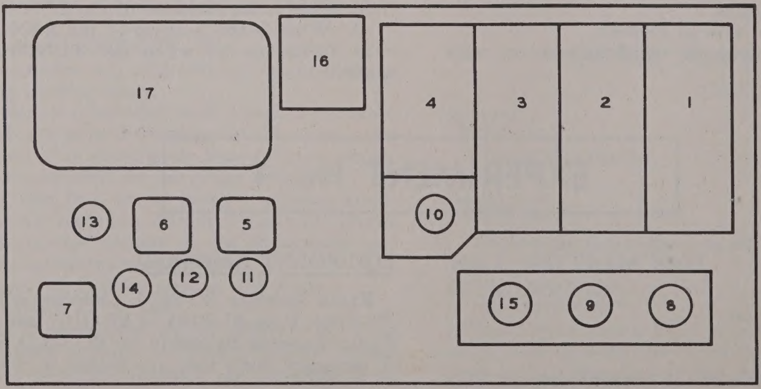
a. Push the chassis into the cabinet; the end plates act as runners.

b. Turn the thumbscrew rods until they are tight.

CONCLUSIONS

1. By what means is the receiver cabinet locked to the mounting?
2. What device is used to fasten the chassis to the cabinet?
3. What are the end-plates of the chassis used for?
4. How is the receiver turned on? What other uses does this switch have?
5. Name one method of controlling the selectivity of the receiver from the front panel.
6. How many jacks are there for headphone connection?
7. When is the C. W. OSC. switch used?
8. What are the two primary functions of the TUNING control?
9. How many tubes are there in the receiver? How many transformers?
10. By what means is the pitch of a c-w signal varied?

ITEM No.	REFERENCE SYMBOL	FUNCTIONAL TITLE
1	190	Antenna Unit
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		



TP 9296

LECTURE No. 3

FUNCTIONAL BLOCK ANALYSIS

The functional block diagram of Radio Receiver BC-348-J is shown in figure 5, and it is also provided on Wall Chart No. 1. This diagram will aid in understanding the operation of the receiver.

The 1st r-f stage is tuned to the frequency of the desired signal; its function is to select and amplify the desired signal, and reject the unwanted signals. The input circuit is designed to operate most efficiently with antennas having capacities ranging from 50 to 250 mmf. The receiver may be used with any type of antenna, but the most suitable antenna is one which has the greatest effective length away from the grounded metal fuselage. Most of the components for the 1st r-f amplifier stage are contained in a shielded unit, which is at the extreme right rear of the chassis, when viewed from the front. The letters ANT. are stamped on the unit, and it is so designated in figure 2, which shows the location of the shielded units.

The 2nd r-f stage has a function similar to that of the 1st r-f stage; that is, preselection and amplification of the desired signal, and rejection of the unwanted signals. The components of the output circuit of the 1st r-f stage and of the input circuit of the 2nd r-f stage are contained in a shielded unit designated as the R. F. unit (see figure 2). This unit is located just to the left of the shielded ANT. unit in the receiver chassis.

The 1st-detector and heterodyne-oscillator stages employ the same tube. The 1st detector includes the third tuned circuit for r-f preselection. It also provides a means of mixing the selected r-f signal with the output of the heterodyne oscillator, with the result that the output of the 1st detector-heterodyne oscillator tube is an intermediate frequency (915 kc.). The components which make up the 1st-detector stage are contained in a shielded unit together with components of the output circuit of the 2nd r-f stage. The container is designated as the DET. unit (see figure 2), and is located just to the left of the shielded R. F. unit in the receiver chassis.

The heterodyne oscillator stage generates the signal which is mixed with the incoming r-f signal to produce the i-f signal. The components for the tuned circuits in the oscillator stage are ganged with similar components in the r-f and 1st-detector stages. The result is that, for all settings of the tuning dial, the output of the heterodyne oscillator stage is such that when it is mixed with the incoming r-f signal in the electron stream of the 1st detector, heterodyne oscillator tube, the output of this tube is always an intermediate frequency of 915 kc. If the incoming signal is modulated (as in the reception of voice signals), the same pattern of audio modulation will appear on the 915-kc. signal.

The components for the heterodyne-oscillator stage are contained in a shielded unit located to the left of the shielded DET. unit in the receiver chassis; this unit is designated as the OSC. unit.

In order to secure a high degree of selectivity, the receiver has three i-f stages. These stages are sharply tuned to pass the i-f signal and reject unwanted signals. They also provide additional amplification of the signal. The three tuned i-f transformers, which serve to couple the i-f stages, are contained in separate shielded cans on the top of the chassis (see figure 2) and are marked for identification.

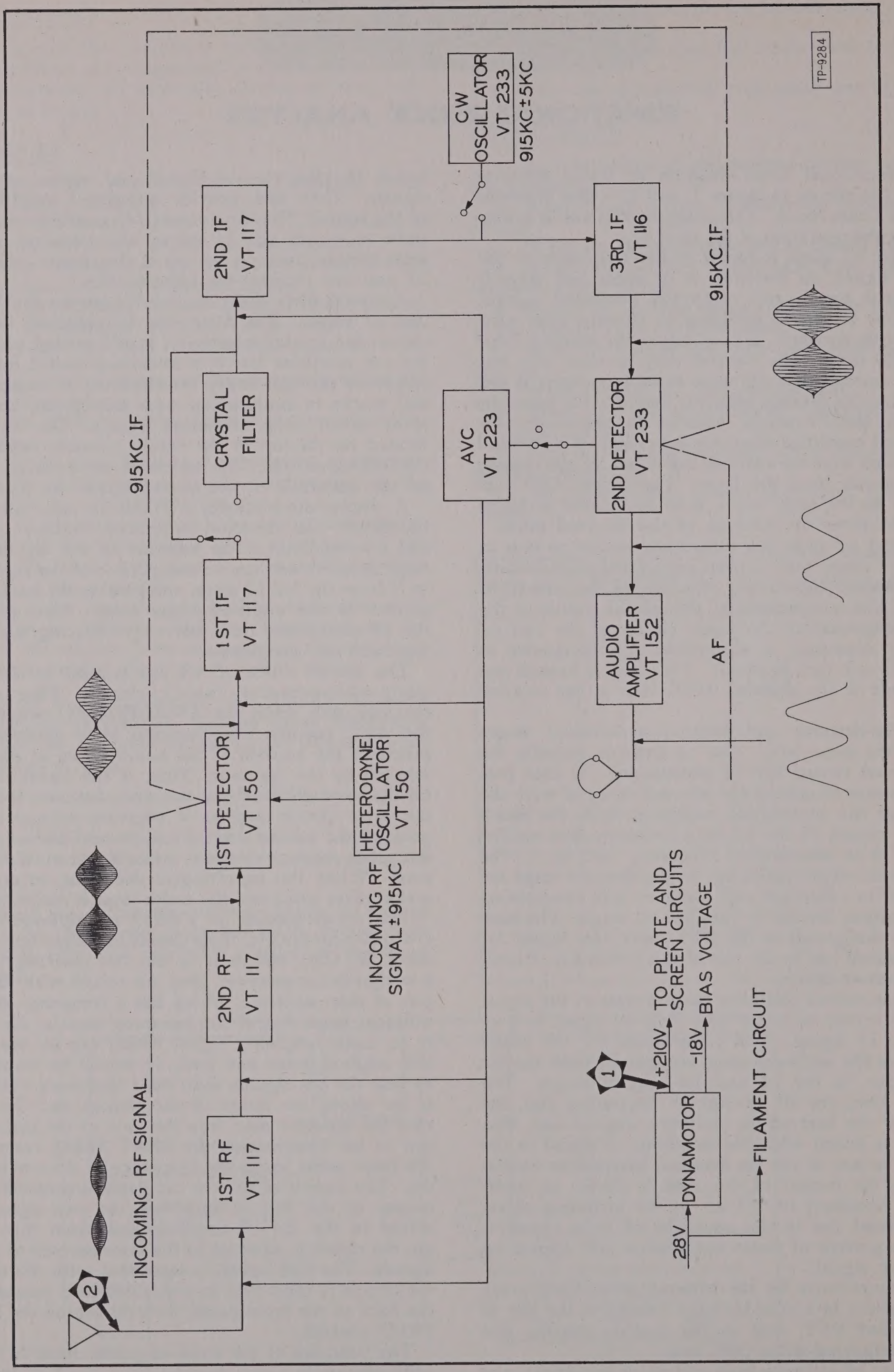
A crystal filter is in the circuit between the 1st and 2nd i-f stages. The filter may be switched into the circuit for greater selectivity; it is intended primarily for c-w reception but it is sometimes useful for voice reception through heavy interference. A neutralizing coil works in conjunction with the crystal, and aids it by neutralizing unwanted signals. The crystal is located on the top of the chassis, directly behind the CRYSTAL switch. The associated neutralizing coil is on the underside of the chassis below the crystal.

A duplex-diode-triode, VT-233, is used for three functions: 2nd detector, automatic volume control, and c-w oscillator. The function of the 2nd-detector stage is to remove the i-f component of the signal fed to it from the 3rd i-f stage, and pass on the audio component to the audio-amplifier stage. This prevents the i-f component from adversely affecting the audio stage and the headphones.

The second diode of VT-233 is used in the automatic-volume-control (a-v-c) circuit. Thus circuit operates only when the AVC-OFF-MVC switch is in the AVC position. Its function is to automatically maintain the volume of the audio signal at the level selected by the operator. Thus, if the signal coupled to the a-v-c diode from the 2nd detector increases, the a-v-c circuit applies a negative voltage to the grids of the 1st and 2nd r-f and 1st and 2nd i-f amplifier tubes, thus reducing the audio signal to its original level. When the input signal decreases, an opposite action takes place and the audio level is maintained.

The triode section of VT-233 is employed in the c-w oscillator circuit. This circuit functions only when the C.W. OSC. switch is in the ON position. When c-w signals are received, they are mixed with the output of this oscillator, which has a frequency slightly different from that of the incoming signals; the result is an audio-frequency signal which can be heard. If this method were not used, it would be impossible to hear the c-w signals since their frequency (915 kc.) is far above the range of the human ear. In order that the operator may vary the tone of the audio output in his headphones, the BEAT FREQ. control on the front panel varies the frequency of the c-w oscillator. The output of the c-w oscillator is coupled to the output of the 2nd i-f amplifier; the two signals are mixed in the 3rd i-f amplifier and, from that point on, the signal is acted on in the same manner as phone signals. The coil assembly associated with the oscillator circuit is contained in a shielded unit mounted on the back of the front panel, directly behind the BEAT FREQ. control.

The function of the audio-amplifier stage is to amplify the audio signal coming from the 2nd detector. The output of the audio-amplifier tube is fed to the



INCOMING RF SIGNAL
1ST RF VT 117
2ND RF VT 117
1ST DETECTOR VT 150
HETERODYNE OSCILLATOR VT 150
INCOMING RF SIGNAL ± 915KC
1ST IF VT 117
915KC IF
CRYSTAL FILTER
2ND IF VT 117
AVC VT 223
CW OSCILLATOR VT 233
915KC ± 5KC
3RD IF VT 116
915KC IF
2ND DETECTOR VT 233
AUDIO AMPLIFIER VT 152
AF
DYNAMOTOR
28V
+210V
TO PLATE AND SCREEN CIRCUITS
-18V
BIAS VOLTAGE
FILAMENT CIRCUIT
①
②
TP-9284

Figure 5. Functional Block Diagram

headphone jacks on the front panel, and through an audio transformer to the interphone terminals on the connector plug.

Power is supplied to the receiver by the dynamotor. It provides 210 volts for the high-voltage plate and screen circuits and minus 18 volts for the biasing of certain tubes.

The dynamotor unit requires an input voltage of 28 volts, and this same voltage is supplied for the filament circuit.

Major test point 1 checks the operation of the power supply; major test point 2 checks the overall operation of the receiver.

LESSON PLAN No. 3

TIME ALLOTTED: ¾ HR.

SUBJECT

Functional block analysis.

OBJECTIVE

To describe the functioning and interrelation of the various stages of Radio Receiver BC-348-J by means of a block analysis.

INTRODUCTION

Radio Receiver BC-348-J can be analyzed by dividing its circuits into a number of blocks that represent the functions which the various stages perform. Basically, the receiver can be thought of as having an r-f group of stages, an i-f group, and an a-f group. In addition, there are a number of stages which perform specialized functions.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram).
2. Place Radio Receiver BC-348-J (with cabinet removed) in view of students, in such a position that they can see the interior of the chassis.
3. Discuss the following items for each functional block:
    a. 1st and 2nd r-f amplifiers.
        (1) Function — preselect and amplify desired signal.
        (2) Type of antenna used.
        (3) Actual physical location of components in receiver.
    b. 1st detector.
        (1) Function — contains third r-f preselection circuit and aids in mixing to provide i. f.
        (2) Uses same tube as heterodyne-oscillator circuit.
        (3) Actual physical location of components in receiver.
    c. Heterodyne oscillator.
        (1) Function — generates signal which is mixed with the incoming r-f signal to produce an i-f signal.
        (2) Use of ganging to produce constant difference in frequency.
        (3) Actual physical location of components in receiver.
    d. 1st, 2nd and 3rd i-f stages.
        (1) Function — selectivity and amplification of i-f signals.
        (2) Actual physical location of i-f transformers in receiver.
    e. Crystal filter.
        (1) Function — provides additional selectivity when desired.
        (2) Use of neutralizing coil.
        (3) Actual physical location of crystal and coil in receiver.
    f. 2nd detector.
        (1) Function — removes i-f component of signal.
        (2) Uses same tube as a-v-c and c-w oscillator circuits.
    g. A. V. C.
        (1) Function — automatically maintains volume at level selected by operator.
        (2) Operates only when AVC-OFF-MVC switch is in AVC position.
        (3) Uses second diode of VT-233.
        (4) Coupled to 2nd detector.
    h. C-w oscillator.
        (1) Function — aids in producing audio tone for c-w reception.
        (2) Uses triode section of VT-233.
        (3) Operates only when C.W. OSC. switch is in ON position.
        (4) Use of BEAT FREQ. control.
        (5) Coupling and mixing with c-w signal.
        (6) Actual physical location of coil assembly in receiver.
    i. Audio amplifier.
        (1) Function — amplifies audio signal.
        (2) Output goes to headphone jacks and connector plug.
    j. Dynamotor.
        (1) Function — provides high voltage and bias voltage.
        (2) Input requirements.
4. Explain the location and use of major test points 1 and 2
5. Review safety precautions and first-aid measures.

CONCLUSIONS

Radio Receiver BC-348-J has two r-f stages, three i-f stages, and one a-f stage. It employs a heterodyne oscillator to secure an i.f. of 915 kc., a crystal filter for optional added selectivity, a c-w oscillator for c-w reception, and a circuit for a.v.c. when desired.

ORAL QUIZ

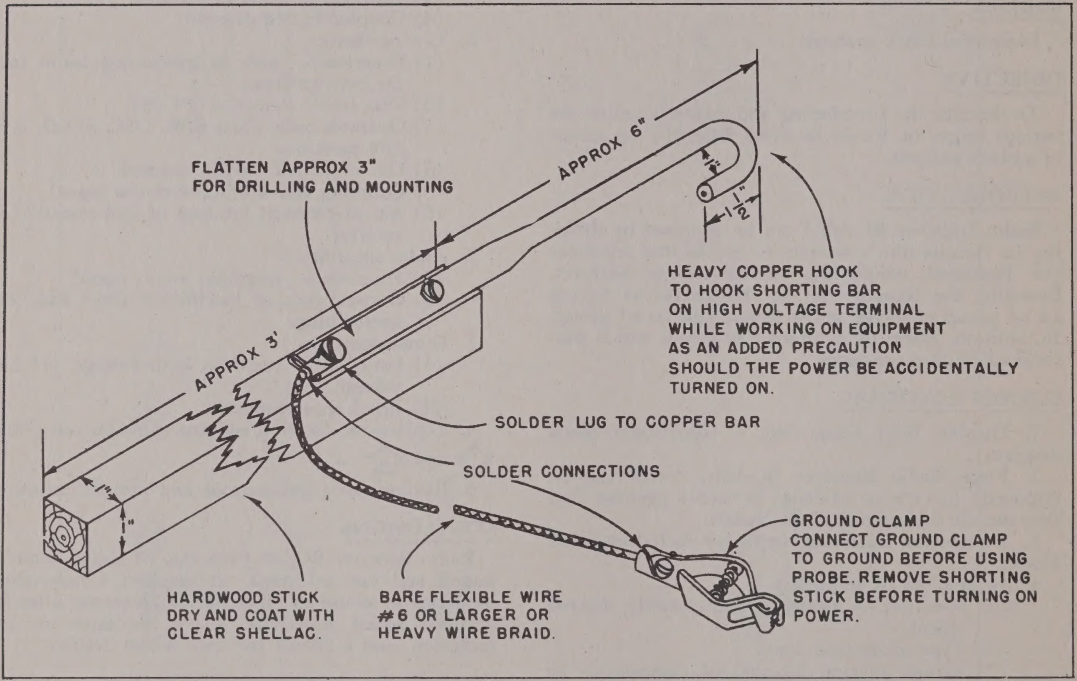
1. What is the most efficient type of antenna which can be used with Radio Receiver BC-348-J?
2. Which stages have r-f preselection circuits?
3. Which is the first stage that has a 915-kc. frequency present in its output?
4. Name the two principal functions of the i-f stages.
5. To which stages is the a-v-c voltage applied?
6. What is the approximate frequency of the output of the c-w oscillator?
7. Give a general description of the input and output signals of the 2nd-detector stage on voice reception.
8. At what points is the output of the audio amplifier made available?
9. What voltages does the dynamotor supply?
10. What is the purpose of the two major test points?

SAFETY PRECAUTIONS

It is the duty of all personnel engaged in the installation, operation, and maintenance of this equipment, or engaged in the training of other personnel on this equipment, to become familiar with the following safety precautions.

1. Do not rely on safety devices such as interlocks and high-voltage relays.
2. Use rubber gloves at all times.
3. Keep your feet clear of objects on the floor.
4. Stand on a good rubber mat.
5. Keep one hand behind you, or in your pocket.
6. Have another person, qualified in first aid for electrical shock, present at all times.
7. Use shorting stick (see illustration).
8. Use approved fuse pullers.

Remember that men are always injured or killed by high-voltage equipment which is assumed to be off. Take nothing for granted. Make certain that the power is off by securing the power-line switch in its OFF position.


FLATTEN APPROX 3" FOR DRILLING AND MOUNTING
APPROX 6"
½"
1½"
HEAVY COPPER HOOK TO HOOK SHORTING BAR ON HIGH VOLTAGE TERMINAL WHILE WORKING ON EQUIPMENT AS AN ADDED PRECAUTION SHOULD THE POWER BE ACCIDENTALLY TURNED ON.
APPROX 3'
SOLDER LUG TO COPPER BAR
SOLDER CONNECTIONS
1"
1"
GROUND CLAMP CONNECT GROUND CLAMP TO GROUND BEFORE USING PROBE. REMOVE SHORTING STICK BEFORE TURNING ON POWER.
HARDWOOD STICK DRY AND COAT WITH CLEAR SHELLAC.
BARE FLEXIBLE WIRE #6 OR LARGER OR HEAVY WIRE BRAID.

FIRST AID

Do These Three Things First in Any Emergency Requiring First Aid

1. **Send for a doctor or carry the victim to a doctor.**
2. **Keep victim warm, quiet, and flat on his back.**
3. **If breathing has stopped, apply artificial respiration. Stop all serious bleeding.**

When, from any cause whatever, breathing has stopped, apply artificial respiration immediately and continue WITHOUT STOPPING until normal breathing returns, or a doctor pronounces the victim dead. SPEED IN BEGINNING ARTIFICIAL RESPIRATION IS ESSENTIAL.

FIRST AID (Cont.)

The Prone Pressure Method of Artificial Respiration

If Due to Electric Shock

1. PROTECT YOURSELF with DRY insulating material.

2. BREAK THE CIRCUIT by opening the power switch or pulling the victim free of the live conductor. DON'T TOUCH THE VICTIM WITH YOUR BARE HANDS UNTIL THE CIRCUIT IS BROKEN.

3. SPREAD DRY BLANKET ON THE GROUND, and roll victim to center of blanket with his arms extended over his head, so that he lies FACE DOWN on blanket.

4. BEND ONE OF THE VICTIM'S ARMS at the elbow and rest victim's cheek on the back of his hand.

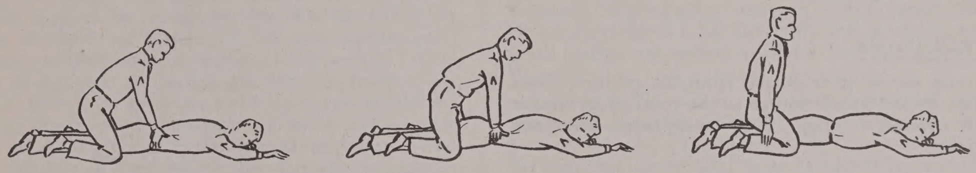
5. REMOVE FALSE TEETH, gum, candy, tobacco, food, etc., from victim's mouth.

6. LOOSEN ALL TIGHT CLOTHING, as belts or collars.

7. COVER VICTIM LOOSELY by wrapping the ends of the blanket around him.

8. STRADDLE VICTIM across thighs.

9. PLACE THE PALMS OF YOUR HANDS ON VICTIM'S BACK so that the little fingers of each hand just touch the victim's lowest ribs.



(1) Straddle victim across thighs. Place the palms of your hands on the victim's back so that the little fingers of each hand just touch the victim's lowest ribs.

(2) Keep your arms stiff and straight and swing your body forward, allowing your weight to bear down on victim. DO NOT PUSH OR USE FORCE.

(3) Swing back at once to relieve pressure, and then continue the rhythmic application of alternate pressure and release.

Blanket is not shown in above drawings for the sake of clarity.

10. KEEP YOUR ARMS STIFF AND STRAIGHT and swing your body forward, allowing your weight to bear down on the victim.
11. DO NOT PUSH OR USE FORCE.
12. SWING BACK AT ONCE TO RELIEVE PRESSURE.
13. REPEAT Step 10.
14. REPEAT Step 12.
15. CONTINUE as above, maintaining a steady rhythm until victim regains consciousness or is pronounced dead by a doctor.
16. CONTINUE ARTIFICIAL RESPIRATION even after victim begins to breathe, and until he becomes conscious.
17. IF BREATHING STOPS AGAIN, continue artificial respiration at once.
18. DO NOT GIVE UP HOPE of reviving the victim. Four hours or more of continuous application of artificial respiration may be required before consciousness returns.

19. NEVER TRY TO FORCE LIQUIDS down an unconscious person's throat. He will drown.

20. ALWAYS WAIT UNTIL CONSCIOUSNESS RETURNS before administering liquid stimulants.

21. RECOMMENDED STIMULANTS ARE: Hot, black coffee. Strong, hot tea. Aromatic spirits of ammonia, one teaspoonful to a glass of water.

22. GIVE ONLY ONE STIMULANT, which should be sipped slowly.

23. ALCOHOLIC DRINKS are not recommended, unless absolutely nothing else is available.

24. When VICTIM HAS RETURNED TO CONSCIOUSNESS, allow him to lie quietly where he is for at least one hour, taking care that he is well covered and free from worry.

25. IF POSSIBLE, CARRY, OR HAVE HIM CARRIED TO A DOCTOR.

EXPERIMENT No. 2

TIME ALLOTTED: ¾ HR.

SUBJECT

Major test points in Radio Receiver BC-348-J.

OBJECTIVE

To become familiar with the locations of, and the normal indications present at, the major test points.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J.
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-F signal generator (200 kc. to 18 mc.).
1 D-C voltmeter with 300-volt range (20,000 ohm per volt meter preferred).
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Connect the 28-volt power source to the receiver by means of the connector plug. Plug headphones into the TEL. jack.

PROCEDURE

1. Set the receiver controls as follows:
   a. DIAL LIGHTS control fully clockwise.
   b. INCREASE VOL. control fully clockwise.
   c. C.W.OSC. switch to OFF.
   d. CRYSTAL switch to OUT.

2. Major test point ① is located at the plus and minus high-voltage terminals of the dynamotor terminal strip (422). These terminals are made available at a cutout in the left end-plate just below the dynamotor. Connect the d-c voltmeter (300-volt range) between the two terminals. CAUTION: HIGH VOLTAGE IS PRESENT ACROSS THESE TERMINALS.

3. Turn the receiver AVC-OFF-MVC switch to AVC. This closes the 28-volt d-c line to the dynamotor; the dynamotor will start and dial lamps will light. The d-c voltmeter should read +200 to +250 volts, indicating that the power supply is functioning properly. Turn the AVC-OFF-MVC switch to OFF. Disconnect the voltmeter leads.

4. Major test point ② is located at the antenna binding post 174-1 on the front panel of the receiver. Connect the r-f signal generator between the test point and ground. Set the signal generator for a weak, unmodulated output.

5. Set the AVC-OFF-MVC switch on the receiver front panel to MVC. Set the C.W. OSC switch to ON. Tune the signal generator to the following frequencies, in succession:

17.0 mc.
13.0 mc.
9.0 mc.
5.0 mc.
3.0 mc.
400 kc.

As the generator is tuned to each frequency, set the BAND SWITCH and TUNING controls on the receiver for the same frequency. Rotate the TUNING control slightly to tune in the signal. For each signal, vary the BEAT FREQ. control. The normal indication at each frequency setting is a whistle in the headphones, which varies in pitch as the BEAT FREQ. control is varied. This indicates that the set is operating properly on each band.

6. Turn the AVC-OFF-MVC switch to OFF and replace the chassis in the cabinet.

CONCLUSIONS

1. Where is major test point ① physically located?

2. If the d-c voltmeter reading at major test point ① is 150 volts, which functional block is probably at fault?

3. Where is major test point ② physically located?

4. If the 9.0-mc. signal (in the experiment above) cannot be tuned in on the receiver, but reception on all other bands is normal, in which functional blocks is the fault probably located?

LECTURE No. 4

CIRCUIT ANALYSIS OF THE 1ST AND 2ND R-F STAGES

The two r-f stages select and amplify the r-f signals picked up by the antenna, prior to passing them on to the 1st-detector stage for mixing. These stages are shown in block form on Wall Chart No. 1 and in schematic form on Wall Chart No. 2. Each stage uses a VT-117 tube (6SK7), which is an r-f pentode with the remote cut-off characteristics required for A-V-C operation.

1ST R-F STAGE

The signal on the antenna is fed to the 1st r-f amplifier by means of an r-f transformer; there are six of these transformers, one for each band. The secondary coils, in each case, form tuned circuits with associated capacitors, each circuit being tuned to the appropriate frequency band. The correct set of coils is placed into the circuit by means of the BAND SWITCH control on the front panel. This control mechanically operates a two-section six-position wafer switch (161), which is ganged to similar switches in three other stages (2nd r-f, 1st detector, and heterodyne oscillator) for the simultaneous selection of those components which tune the circuits to the desired frequency range.

The schematic diagram of the r-f stage (figure 6) shows the wafer switch in the band 6 position (13.5—18.0 mc.). The antenna binding post (174-1) is coupled to transformer 125 by means of a compensating circuit composed of capacitors 22 and 41, in series and in parallel, respectively, with the primary coil; this circuit is used to achieve uniform transfer of the r-f energy on the antenna to the 1st r-f stage at all frequencies. The secondary coil of the transformer forms a tuned circuit with fixed capacitors 9 and 32, trimmer capacitor 2-3B, and tuning capacitor 1-A. The variable tuning capacitor, which is ganged with similar capacitors in three other stages (2nd r-f, 1st detector, and heterodyne oscillator) is operated by the TUNING control, and it smoothly varies the capacitance of the tuned circuit, thus permitting continuous tuning through the band. Capacitors 9 and 32 act as fixed band-spread capacitors. Capacitor 9 lowers the maximum capacitance limit, and capacitor 32 raises the minimum capacitance limit of tuning capacitor 1-A; thus, the tuning range is reduced, resulting in easier and more accurate tuning. A similar band-spread arrangement is used for band 5. Trimmer capacitor 2-3B permits adjustment of the circuit, in the shop, when the receiver becomes misaligned. This trimmer, and similar ones in other tuned circuits throughout the r-f, 1st detector, and heterodyne-oscillator stages, are easily available for adjustment (see figure 7).

Capacitor 53, which is connected between the primary and secondary coils of the transformer, is used because of the distributed capacitance which exists between the unshielded coils. Ordinarily, the distributed capacitance has the effect of producing a greater amount of coupling action between the coils of the selected transformer as the frequency increases. Because of this effect, capacitor 53 is used on all bands and capacitors 55 and 56 are used in the band-1 and band-2 circuits, respectively, to make the coupling uniform over the entire frequency range of the receiver.

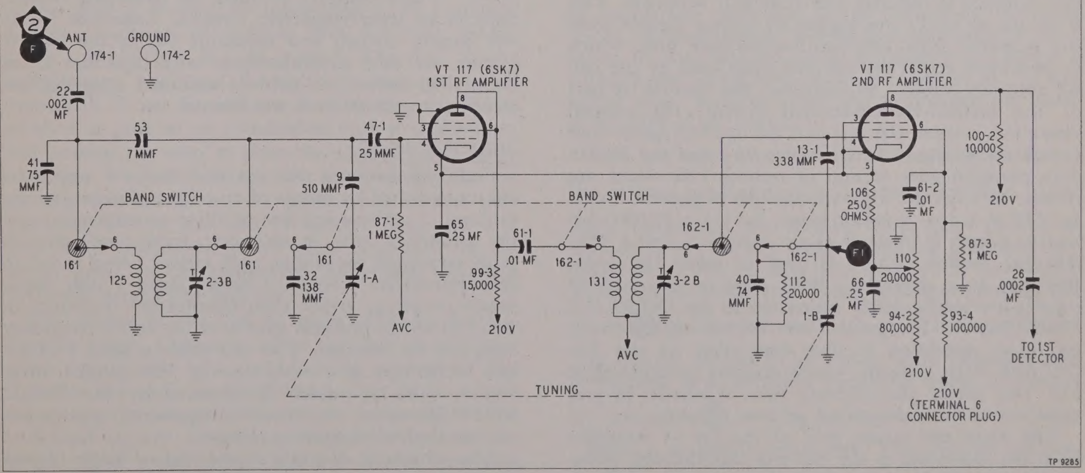

2
F
ANT
174-1
GROUND
174-2
22
.002
MF
41
75
MMF
53
7 MMF
47-1
25 MMF
9
510 MMF
VT 117 (6SK7)
1 ST RF AMPLIFIER
8
3
4
5
6
BAND SWITCH
161
125
2-3B
32
138
MMF
1-A
87-1
1 MEG
AVC
65
.25 MF
61-1
.01 MF
99-3
15,000
210 V
162-1
131
3-2 B
AVC
40
74
MMF
112
20,000
1-B
13-1
338 MMF
VT 117 (6SK7)
2ND RF AMPLIFIER
106
250
OHMS
61-2
.01
MF
F1
110
20,000
66
.25
MF
94-2
80,000
210 V
93-4
100,000
210 V
(TERMINAL 6
CONNECTOR PLUG)
87-3
1 MEG
100-2
10,000
210 V
26
.0002
MF
TO 1ST
DETECTOR
TUNING
TP 9285

Figure 6. 1st and 2nd R-F Amplifier Circuits (Band 6)

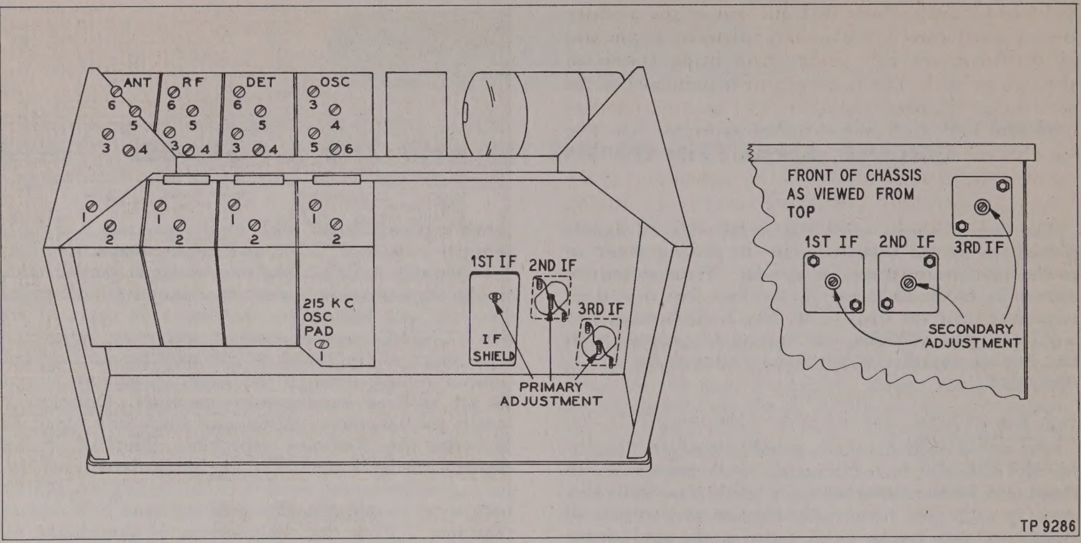


Figure 7. Location of Trimmer Capacitors and I-F Transformer-Core Adjustments

The signal selected by the tuned circuit is applied to the control grid of the 1st r-f amplifier tube (VT-117); the signal voltage is developed across grid resistor 87-1, which also serves to connect the grid to the a-v-c circuit. Resistor 87-1 has a value of one megohm, which is high enough so that the Q of the selected tuned circuit, across which it is shunted, will not be affected adversely. Capacitor 47-1 prevents the a-v-c voltage from being grounded through the tuned circuit in the 1st r-f stage.

The 1st r-f amplifier tube, although a pentode, is triode-connected. The suppressor grid is grounded, and the screen grid is directly connected to the plate. Since the tube operates as a triode rather than as a pentode, the amount of amplification which the tube can produce is reduced, but it is still adequate; also, it is not so easily overloaded by strong signals from the antenna. The tube utilizes cathode bias, which is developed across resistor 106 (also used by the 2nd r-f amplifier tube). In addition, this resistor is part of the manual-volume-control circuit; for manual operation, resistor 106 is connected to a voltage-divider circuit consisting of fixed resistor 94-2 and the 20,000-ohm potentiometer section of resistor 110, which are connected from the high-voltage bus to ground. Resistor 110 is a dual potentiometer, having a 20,000-ohm section which is used on m-v-c operation, and a 350,000-ohm section, which is used to select the audio level on a-v-c operation; both arms of the potentiometer are mechanically connected to the INCREASE VOL. control. The gain of the 1st r-f amplifier tube on m-v-c operation is thus controlled by the INCREASE VOL. control, which actuates potentiometer 110 and varies the cathode bias. Cathode by-pass capacitor 65 provides an r-f path to ground.

The plate and screen grid of the 1st r-f amplifier tube are connected to the 210-volt line through plate-load resistor 99-3, across which the r-f signal voltage is developed; this resistor also drops the d-c voltage to the proper level for the plate and screen. Capacitor 61-1, in the plate circuit, acts as a d-c blocking capacitor.

The 1st r-f circuits for operation on bands 3, 4 and 5 are quite similar to the circuit just described, although it may be noted that fixed band-spread capacitor 9 is used only on bands 5 and 6. Otherwise, the only changes are the different transformers, with properly tuned secondaries, which are selected by the wafer switch. The circuits for bands 1 and 2 have several additional features. Transformer 120 is used in the band-1 circuit, and the primary coil is shunted by resistor 88; transformer 121 is used in the band-2 circuit, and the primary coil is shunted by resistor 100-1. These resistors broaden the band-pass characteristics of their respective circuits. Capacitor 55, in the band-1 circuit, and capacitor 56, in the band-2 circuit, are used in conjunction with capacitor 53, as mentioned before, to achieve uniform coupling between the coils of each transformer.

2ND R-F STAGE

Coupling between the 1st and 2nd r-f amplifiers is accomplished by means of an r-f transformer, except on band 1. There are five of these transformers, and the secondary coils, in each case, form tuned circuits with associated capacitors, each circuit being tuned to the appropriate frequency band. Band 1 uses impedance coupling, rather than transformer coupling, in order to secure uniform gain over the entire frequency range of the receiver. The coil used on band 1 (126) also forms part of a tuned circuit. The ganged wafer switch (162-1), which is operated by the BAND SWITCH, selects the circuit components appropriate to the desired frequency range.

The schematic diagram of the 2nd r-f stage (figure 6) shows the wafer switch in the band-6 position

(13.5—18.0 mc.). Note that one end of the primary coil of transformer 131 is directly connected to one end of the secondary coil, rather than being connected through ground. The tuned circuit is composed of the secondary coil, fixed capacitors 13-1 and 40, trimmer capacitor 3-2B, and ganged tuning capacitor 1-B. The variable tuning capacitor is operated by the TUNING control, and it smoothly varies the capacitance of the tuned circuit, thus permitting continuous tuning through the band. Capacitors 13-1 and 40 act as fixed band-spread capacitors, in the same manner as the similar arrangement in the 1st r-f stage; resistor 112, shunted across capacitor 40, broadens the band-pass width of the circuit. This method is also employed in the band-5 circuit. Trimmer capacitor 3-2B permits adjustment of the circuit, in the shop, when the receiver becomes misaligned.

The a-v-c circuit is connected to the grid of the 2nd r-f amplifier tube through the secondary coil of the transformer. An a-v-c filter network is utilized in this stage; for band 6 operation, it consists of resistor 98-1 and capacitor 20-1. These components are used on all bands, but for bands 3 and 4 the filter circuit is expanded to include resistors 93-1 and capacitor 23-1. The use of these components will be considered when the a-v-c circuit is discussed.

The r-f signal selected by the tuned circuit is applied to the control grid of the 2nd r-f amplifier tube (VT-117), which is a pentode. This tube uses the same cathode-biasing resistor utilized by the let r-f amplifier tube (106); this resistor is connected to the manual-volume-control circuit. Therefore, the gain of the 2nd r-f amplifier tube is also controlled by the INCREASE VOL. control on m-v-c operation. Cathode by-pass capacitor 65 provides an r-f path to ground.

The suppressor grid of the 2nd r-f amplifier tube is connected directly to the cathode. The plate is connected to the high-voltage bus through plate-load resistor 100-2, across which the r-f signal voltage is developed; this resistor also drops the d-c voltage to the proper level for the plate. The d-c voltage for the screen grid is secured by connecting it to a voltage divider consisting of resistors 87-3 and 93-4, which are connected from B+ to ground. The line to the high-voltage bus goes through the connector plug (terminals 2 and 6) and the transmitter relay if the receiver is used in an installation with a transmitter, this permits the relay to place the receiver in stand-by condition when the transmitter is operating, by removing the voltage on the screen grid of this tube (and also the 1st and 2nd i-f tubes). Capacitor 61-2 provides a low-impedance r-f path to ground for the screen grid. In the transmitter relay line, capacitor 61-10 also acts as a by-pass for r-f.

The output of the 2nd r-f stage is fed to the 1st-detector stage. Capacitor 26 in the 2nd r-f amplifier plate circuit acts as a d-c blocking capacitor. The signal at this point is somewhat greater in amplitude than when it entered the receiver, and many of the undesired signals have been eliminated by the two stages of r-f preselection. The 1st detector provides further preselection.

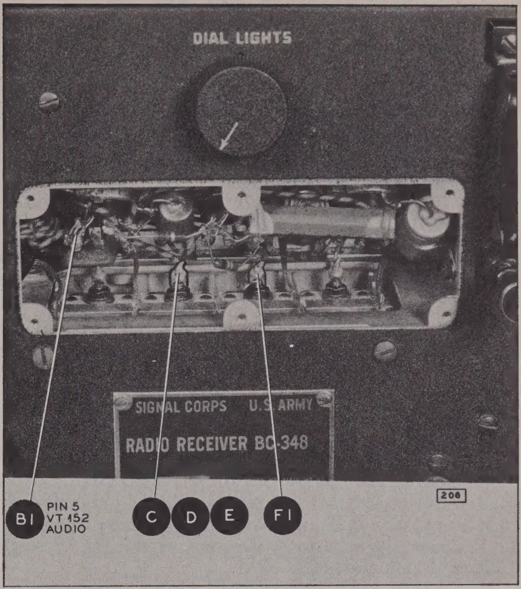


Figure 8. Location of Test Points B1, C, D, E, and F1

The 2nd r-f circuits for operation on bands 2, 3, 4, and 5 are quite similar to the circuit just described, although it may be noted that fixed band-spread capacitor 13-1 is used only on bands 5 and 6. Also, as mentioned before, the a-v-c filter network is different for certain bands. Otherwise, the only changes are the different transformers, with properly tuned secondaries, which are selected by the wafer switch.

When the wafer switch is in position for band-1 operation, the 1st and 2nd r-f stages are impedance-coupled. Coil 126 forms a tuned circuit with trimmer capacitor 3-1A and tuning capacitor 1-B. In order to limit the gain when this circuit is used, so that it will be comparable with that of the circuits for the other bands, an arrangement is used in which resistor 107-1 serves to attenuate the signal sufficiently to provide a suitably low signal level at the grid of the 2nd r-f amplifier tube. Resistor 109-1 acts to broaden the band-pass width of the circuit.

The key test point for the r-f stages is located at the antenna binding post, and is designated F. After other circuits in the receiver have been cleared of trouble by the use of a trouble-shooting procedure, the operation of the r-f circuits is checked by connecting an amplitude-modulated signal generator between test point F and ground, and listening in the headphones. The normal indication is a clear tone. Trouble may be isolated to a particular circuit by means of secondary test point F1, and by making use of key test point F as a secondary test point. The physical location of F1 is shown on figure 8.

LESSON PLAN No. 4

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of the 1st and 2nd r-f stages.

OBJECTIVE

To analyze the r-f amplifier circuits.

INTRODUCTION

The initial selection and amplification of the desired signal takes place in the two r-f stages.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram, and briefly review the action of the two r-f amplifiers.
2. Display Wall Chart No. 2 and point out the 1st and 2nd r-f circuits.
3. State the type of tube used in both stages.
4. Discuss the use of the BAND SWITCH control and wafer switch 161 for selecting the r-f transformer and tuned-circuit components for the desired band.
5. Draw the schematic diagram of the 1st r-f stage (figure 6) on the blackboard.
6. Discuss the compensating circuit composed of capacitors 22 and 41.
7. Point out the components in the tuned circuit for band-6 operation. Discuss the use of the tuning capacitor, fixed band-spread capacitors, and the trimmer capacitor.
8. Point out capacitor 53 and explain its use for uniform coupling on all bands. Mention the use of capacitors 55 and 56 for this purpose.
9. Point out the a-v-c connection to the 1st r-f amplifier control grid, and explain the use of resistor 87-1 and capacitor 47-1.
10. Discuss the use of VT-117 as a triode in the 1st r-f stage.
11. Point out cathode resistor 106 and explain its use with the m-v-c circuit.
12. Describe the screen-grid and plate circuits.
13. Discuss the circuits for the other bands, and point out the variations in the band-1 and band-2 circuits.
14. Draw the schematic diagram of the 2nd r-f stage (figure 6) on the blackboard, showing the connections to the 1st r-f stage.
15. Explain the coupling used between the 1st and 2nd r-f stages; mention impedance coupling on band 1.
16. Point out the components in the tuned circuit for band-6 operation. Discuss the use of the tuning capacitor, fixed band-spread capacitors, and the trimmer capacitor. Mention the use of resistor 112.
17. Point out the a-v-c connection to the 2nd r-f amplifier control grid; mention the use of an a-v-c filter network.
18. Discuss the use of cathode resistor 106, which is also used for the 1st r-f amplifier tube.
19. Describe the plate circuit.
20. Describe the screen-grid circuit; point out the connection to the voltage divider, and the use of the connector plug.
21. Describe the characteristics of the signal at the point where it leaves the 2nd r-f stage.
22. Discuss the circuits for the other bands, and explain the use of impedance coupling in the band-1 circuit.
23. Point out the test points in the circuit and explain their use.
24. Point out the physical locations of the test points on the receiver.

CONCLUSIONS

The two r-f stages perform the same functions, and are somewhat similar in design. An inoperative condition of these stages can be detected by the use of one key test point, and isolated to one stage by making tests at two secondary test points.

ORAL QUIZ

1. What is the purpose of the trimmer capacitors in the various tuned circuits?
2. Why is the screen-grid voltage line in the 2nd r-f stage carried out of the receiver?
3. What happens to the selected tuned circuit when the TUNING control is varied?
4. What type of biasing arrangement is used in the r-f stages?
5. What is the purpose of capacitors 9 and 13-1, in the 1st and 2nd r-f stages?
6. Through what resistor are the plate and screen grid of the 1st r-f amplifier tube connected to the high-voltage bus?
7. What method is used to broaden the band-pass width of certain circuits? Name the circuits in which this method is used.
8. What is the purpose of capacitor 61-1 in the output circuit of the 1st r-f amplifier tube?
9. If one of the fixed capacitors in a tuned circuit of the 2nd r-f stage is defective, what test point would isolate the inoperative stage? Where is this test point located in the circuit?

EXPERIMENT No. 3

TIME ALLOTTED: 2 HR.

SUBJECT

1st and 2nd r-f stages.

OBJECTIVE

To become familiar with the methods used to check the alignment of, and to trouble-shoot, the r-f stages.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J (in good operating condition).
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-f signal generator (200 kc. to 18 mc.).
1 D-c voltmeter with 100-volt and 500-volt ranges (20,000-ohms-per-volt meter preferred).

1 Ohmmeter.
1 Output meter, rectifier type, 0-15 volts, 4000 ohms (contained in Test Set I-56-A and other test sets of the I-56 series).
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Remove the small plate on the front panel. Connect the output meter to terminals 1 and 5 of the connector plug; set the meter for the 15-volt range. Connect the power source to the receiver. Plug headphones into the TEL. JACK. Connect the signal-generator output to the antenna post of the receiver through a 100-mmf. capacitor, and the signal-generator ground lead to the ground post of the receiver, using a short heavy lead.

PROCEDURE

1. Set the signal generator for a modulated output. Turn on the signal generator and adjust it for a weak signal. Set the receiver controls as follows:

a. DIAL LIGHTS control fully clockwise.
b. INCREASE VOL. control fully clockwise.
c. C.W. OSC. switch to OFF.
d. CRYSTAL switch to OUT.
e. AVC-OFF-MVC switch to MVC.

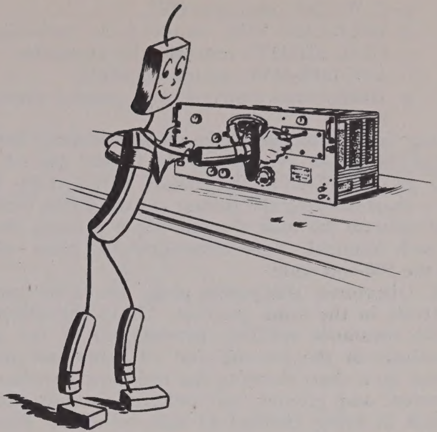
Allow the receiver and signal generator to warm up for several minutes.

2. To check the alignment of the tuned circuits in the r-f stages, locate the trimmer screws for the r-f stages at the rear of the shielded units (ANT. unit for the 1st r-f stage and the R. F. unit for the 2nd r-f stage). The band number is stamped on the chassis near the screws. Tune the receiver and signal generator to 470 kc. Adjust the signal-generator output so that the output meter produces a reading at approximately the center of its scale. With a screwdriver, vary the trimmer screw for band 1 in the 1st r-f stage. Notice that the output reading changes as the screw is varied from its original setting. This indicates that there is a critical setting for the trimmer capacitor to secure maximum output; this trimmer adjustment is used to align the circuit for band 1 in the 1st r-f stage with the other circuits in the receiver used for band-1 operation, with the objective of securing maximum output. Reset the trimmer screw to its proper position by securing the maximum reading on the output meter.

3. Repeat the procedure in paragraph 2 for band 1 in the 2nd r-f stage. The procedure is the same on all bands, and it can be tried on band 4 by setting the signal generator and receiver to 9.0 mc. In all cases reset the trimmer screw to its proper position (as indicated by a maximum reading on the output meter) before proceeding to the next adjustment.

4. The over-all operation of the two r-f stages can be checked by the method of introducing a modulated r-f signal at key test point F, the antenna binding post, and listening to the receiver output. Tune the signal generator to the following frequencies, in succession:

17.0 mc.
13.0 mc.
9.0 mc.
5.0 mc.
3.0 mc.
400 kc.



As the generator is tuned to each frequency, set the BAND SWITCH and TUNING controls on the receiver for the same frequency. Rotate the TUNING control slightly to tune in the signal. A clear tone will be heard in the headphones at each frequency setting; this is the normal indication. In trouble-shooting a receiver which has a defect in the r-f stages, if reception were abnormal on one or more bands but not on all bands, the fault would lie in a component associated with the abnormal bands. If there were no normal indication on any band, the fault would probably be in a component associated with all the bands.

5. Secondary test point F1 is physically located in the opening behind the small removable plate on the front panel of the receiver. When the plate is removed the four-section ganged tuning capacitor is exposed. The test point is at the 2nd r-f section of the capacitor (the second section from the right). Connect the signal-generator output between this test point and ground. The signal-generator and receiver control positions are the same as for key test point F. Follow the same procedure outlined in paragraph 4, tuning the signal generator and receiver to one frequency in each band. The normal indication on each band is a clear tone in the headphones. Note that the signal in the headset is weaker, for the same strength input signal, than when key test point F is used, since there is one stage less of r-f amplification. An abnormal indication, when using test point F1, means that the fault has been isolated to the 2nd r-f amplifier tube or associated components, switch 162-1, or alignment of the band, or bands, for which an abnormal indication is obtained.

6. If the use of secondary test point F1 were to produce a normal indication, in trouble-shooting a defective receiver, it would mean that the trouble was in the 1st r-f stage. This could be checked by using key test point F as a secondary test point, and repeating the procedure outlined in paragraph 4.

7. Set the receiver controls as follows:

a. BAND SWITCH and TUNING set for 200 kc.
b. CRYSTAL switch to OUT.

- c. C. W. OSC. switch to OFF.
- d. INCREASE VOL. control fully clockwise.
- e. DIAL LIGHTS control fully clockwise.
- f. AVC-OFF-MVC switch to MVC.
- g. Headphones, antenna, and ground disconnected.

Using the d-c voltmeter take voltage readings between all of the socket terminals of the 1st and 2nd r-f tubes and ground. CAUTION! HIGH VOLTAGE! Draw up a chart showing the voltage at each socket terminal, and indicate the tube element which is being checked at each terminal. Read screen-grid and plate voltages on the 500-volt scale.

8. Disconnect the power plug. Leave the receiver controls in the same position. Using the ohmmeter, make resistance readings between all of the socket terminals of the 1st and 2nd r-f tubes and ground. Draw up a chart showing the resistance between each terminal and ground, and indicate the tube element which is being checked at each terminal. Readings at terminal No. 4 should be made for both the MVC and AVC positions of the AVC-OFF-MVC switch. All of the other readings are made for the MVC position only.

9. Request the instructor to place a defect in one of the r-f stages. By making use of the test points, isolate the trouble to the individual circuit at fault. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

10. Request the instructor to place another defect in the r-f stages. By making tests at the test points, isolate the trouble to the individual circuit at fault. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

11. Restore the receiver to its original condition.

CONCLUSIONS

1. Why is maximum output a good indication of the proper adjustment of the trimmer capacitors in the r-f stages?

2. How can the r-f stages be aligned without the use of an output meter?

3. If the voltage reading between the plate of the 1st r-f amplifier (socket terminal 8) and ground is zero, which component is probably at fault?

4. List several possible causes of trouble if there is no tone in the headphones when using test point F1 on band-3 operation, but reception is normal on all other bands.

LECTURE No. 5

CIRCUIT ANALYSIS OF THE 1ST-DETECTOR AND HETERODYNE-OSCILLATOR STAGES

The 1st-detector and heterodyne-oscillator circuits operate together to produce an i-f signal of 915 kc. The heterodyne oscillator is the source of the r-f oscillations which are mixed with the incoming r-f signals that have been selected by the 1st-detector circuit. The mixing action occurs in the electron stream of VT-150 (6SA7), a pentagrid converter tube which is utilized by both stages. The 1st-detector and heterodyne-oscillator stages are shown in block form on Wall Chart No. 1 and in schematic form on Wall Chart No. 2.

1ST DETECTOR

The 1st-detector stage provides a third r-f preselection circuit. The six circuits, which are used for the six bands, are somewhat similar in design to those used in the 2nd r-f stage. Coupling between the 2nd r-f and 1st-detector stages is accomplished by r-f transformers (133-137), except for band 1 operation, in which impedance coupling is used. Each band has an appropriate tuned circuit; the transformer and tuned-circuit components suitable for the desired frequency range are selected by the BAND SWITCH control, which operates the ganged wafer switch (162-2). The schematic diagram (figure 9) shows the circuit for band-6 operation (13.5—18.0 mc.). In this position of switch 162-2, transformer 137 is in the circuit, and the tuned circuit is composed of the secondary coil, fixed capacitors 13-2 and 39-2, trimmer capacitor 2-6B, and tuning capacitor 1-C. The ganged tuning capacitor smoothly varies the capacitance of the circuit, so that the circuit can be continuously tuned through the band. Capacitors 13-2 and 39-2 function as fixed band-spread capacitors in the same way as similar capacitors in the two r-f stages, making tuning easier and more accurate. Capacitor 13-2 is also used for band-5 operation. The trimmer capacitor permits adjustment of the circuit in the shop when the receiver becomes misaligned.

The coil-and-capacitor arrangement (152), which is connected between the secondary coil of the transformer and ground, is an i-f filter trap. It is intended to reject any unwanted received signals having the same frequency as the intermediate frequency (915 kc.). This trap is particularly useful when operating on the two lowest bands, where such unwanted signals might appear and be passed on through the i-f amplifier stages to the audio output. The i-f trap, which is composed of capacitor 8 and the coil in series, is resonant at 915 kc.; hence, it offers a low impedance to signals at or near the frequency and shorts them to ground.

The signal selected by the tuned circuit is injected into VT-150 by means of the third grid. This grid has a fixed negative bias consisting of the voltage drop across parallel resistors 108-1 and 108-2, which are in

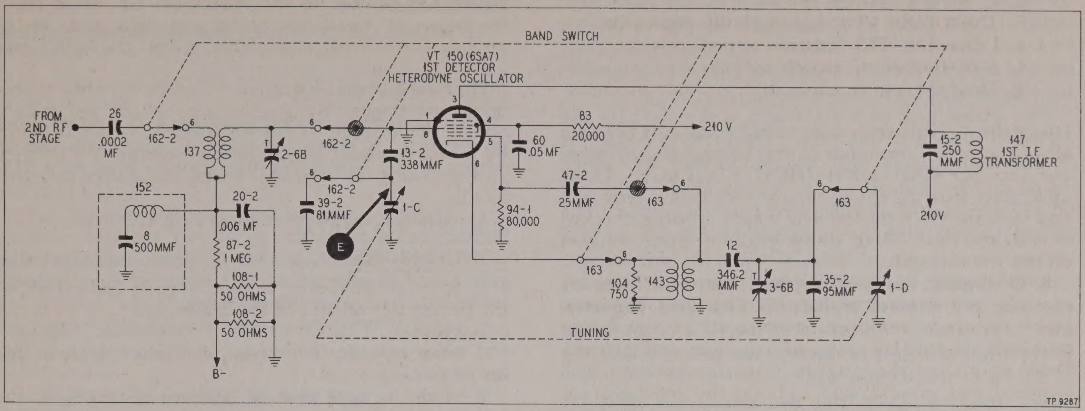
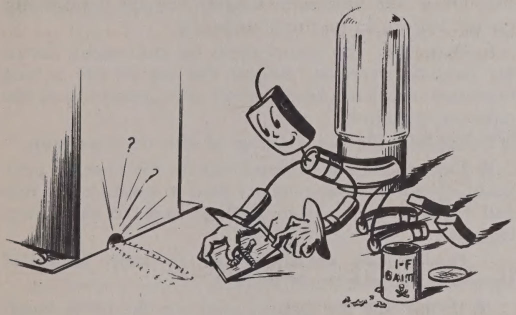


Figure 9. 1st-Detector and Heterodyne-Oscillator Circuit (Band 6)



the negative plate-supply line; the amount of the bias is sufficient for proper operation of the tube, and for the prevention of grid detection, which might produce spurious frequencies in the output. The bias voltage is applied to the grid by means of the transformer secondary. In order to prevent r-f currents in this stage from feeding back to the power supply, a filtering or decoupling network is used in the bias circuit. For switch positions 1, 2, 5, and 6 the filter circuit is composed of capacitor 20-2 and resistor 87-2. For switch positions 3 and 4 the filter circuit is enlarged by the addition of resistor 93-2 and capacitor 23-2.

It is essential that undesired signals be kept at a minimum in VT-150, since the i-f stages will amplify any signal at or near 915 kc. Undesired responses are kept at a minimum by means of the three r-f preselection circuits and the i-f filter trap.

The circuits used for band 2, 3, 4, and 5 are similar in design to the circuit just described; however, as mentioned before, the fixed band-spread arrangement is used only on bands 5 and 6, and the filter circuit in the fixed bias line is enlarged on bands 3 and 4. For band-1 operation, impedance coupling is used for the same reason it is used in the 2nd r-f stage, and the circuit design is similar.

HETERODYNE OSCILLATOR

The heterodyne oscillator employs a tuned-grid circuit, with excitation being secured by means of a cathode coil tightly coupled to the grid coil. There are six tuned-grid circuits and six cathode coils, one for each frequency band; the ganged wafer switch (163) selects the appropriate grid and cathode components for the desired frequency band. On bands 1, 2, 3, and 4 the oscillator operates at a frequency which is 915 kc. *higher* than the received signal; on bands 5 and 6 the oscillator operates at a frequency which is 915 kc. *lower* than the received signal. The use of a lower oscillator frequency on the two highest bands results in an improvement in the image-rejection ratio. In order that the oscillator frequency can be varied smoothly and continuously at the same time that the tuned circuits in the previous stages are tuned through the various bands, capacitor 1-D is ganged with the other main tuning capacitors. This capacitor is in the selected tuned circuit in the oscillator stage. It is by means of the simultaneous tuning that the oscillator frequency is always 915 kc. away from the frequency of the received signal.

Because of the fact that variations in voltage and temperature affect the frequency at which an oscillator operates, provisions are made in this stage to minimize such effects. A standard voltage regulator is not necessary due to the use of a high-value grid-leak resistor (94-1, 80,000 ohms), a low-value grid-coupling capacitor (47-2, 25 mmf.), and a pentagrid converter tube which has good inherent stability. The effects of wide variations in temperature have been reduced to a minimum by the use of a very stable tuning capacitor (1-D) and temperature-compensating fixed ceramic capacitors in each tuned circuit (35-1, 35-2, 42-1, 42-2, 45, 48, and 49-2).

The schematic diagram of the heterodyne-oscillator stage (figure 9) shows the circuit for band-6 operation. The cathode winding of transformer 143 is shunted by resistor 104 to limit the amount of feedback provided for the tuned circuit. (This resistor is not used in Radio Receiver BC-348-Q.) The tuned circuit consists of the secondary winding of the transformer, fixed ceramic capacitor 35-2, trimmer capacitor 3-6B, series padder capacitor 12, and tuning capacitor 1-D. The trimmer capacitor is used for the alignment of the circuit, and the fixed series padder capacitor, which has a critical value, aids in achieving proper tracking of the oscillator circuit with the associated tuned circuits in the r-f and 1st-detector stages. Resistor 94-1 and capacitor 47-2 function as the grid-leak resistor and capacitor, across which self-bias for the oscillator section of VT-150 is developed.

The second grid of VT-150 acts as the plate for the oscillator section of the tube. This grid is connected to the high-voltage bus through resistor 83, which drops the d-c voltage to the proper level. Capacitor 60 provides a low-impedance r-f path to ground. The second grid is directly connected to the fourth grid (screen) and both are kept at the same d-c voltage. The third grid is utilized by the 1st-detector stage for injecting the received signal; the fifth grid (suppressor) is grounded. The plate of the tube is connected to the high-voltage bus through the primary winding of the 1st i-f transformer (147).

The received signal and the oscillator output are mixed in the electron stream of the tube. Although a number of different frequencies are present in the plate circuit, only the intermediate frequency is passed through to the 1st i-f amplifier because the output of the VT-150 is coupled to this amplifier by means of a shielded double-tuned transformer (147) tuned to 915 kc. If voice transmissions are received, the intermediate-frequency signal will contain the same modulation envelope as the original received signal.

The circuits used for bands 2, 3, 4, and 5 are similar to the circuit just described, except that none of the cathode windings are shunted by a resistor; otherwise, the only changes are that different transformers and tuned-circuit components are used for each band. For band-1 operation the tuned circuit is comprised of the grid winding of transformer 138, fixed capacitors 45 and 49-2, trimmer capacitor 3-4A, series padder capacitor 4 (which is adjustable), and tuning capacitor 1-D. The trimmer and padder capacitors make it possible to adjust this circuit for tracking at both the high end (capacitor 3-4A) and the low end (capacitor 4) of the band.

Key test point Ⓔ is used to check the operation of the 1st-detector and heterodyne-oscillator stages. This test point is at the ungrounded side of the 1st-detector section of the four-section ganged tuning capacitor. It is physically located in the opening behind the small removable plate on the front panel of the receiver; the 1st-detector section is the third section from the right (see figure 8). After the circuits following the 1st-detector and heterodyne-oscillator stages are cleared of trouble by the use of a trouble-shooting procedure, the operation of the 1st detector and heterodyne oscillator is checked by connecting a modulated signal generator between test point Ⓔ and ground and listening in the headphones. The normal indication is a clear tone.

LESSON PLAN No. 5

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of the 1st-detector and heterodyne-oscillator stages.

OBJECTIVE

To analyze the 1st-detector and heterodyne-oscillator circuits.

INTRODUCTION

The 1st-detector circuit provides a 3rd stage of r-f preselection; it mixes the selected signal with the r-f output of the heterodyne oscillator to produce a 915-kc. i.f.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram) and briefly review the action of the 1st-detector and heterodyne-oscillator stages.
2. Display Wall Chart No. 2 (schematic diagram) and point out the 1st-detector and heterodyne-oscillator stages.
3. State the type of tube used for both stages.
4. Discuss the method of coupling between the 2nd r-f and the 1st-detector stages, and the use of tuned circuits; point out wafer switch 162-2.
5. Draw the schematic diagram of the 1st-detector circuit (figure 9) on the blackboard.
6. Point out the components in the tuned circuit for band-6 operation; discuss the use of the tuning capacitor, the fixed band-spread arrangement, and the trimmer capacitor.
7. Explain the functioning of the i-f filter trap.
8. Discuss the use of fixed bias on the injector grid, pointing out the components used to produce the bias and to prevent r-f from feeding back to the power supply.
9. Review the methods used to keep undesired signals at a minimum in VT-150.
10. Point out the circuits used for the other bands in the 1st-detector stage and mention the variations from the band-6 circuit.
11. Draw the schematic diagram of the heterodyne oscillator (figure 9) on the blackboard, showing the connections to the 1st-detector circuit.
12. Discuss the type of oscillator and the method of selecting the appropriate circuit components.
13. Explain the frequencies at which the oscillator operates and the reason why the oscillator frequency is lower than the received signal on bands 5 and 6.
14. Discuss the methods used to eliminate the effects of voltage and temperature changes. Point out the components which are used for this purpose.
15. Explain the following items in the heterodyne-oscillator stage for band-6 operation and identify the components:
    a. Resistor 104 shunting the cathode winding; mention that it is not used in Radio Receiver BC-348-Q.
    b. Components of the tuned circuit.
    c. Method of bias and components used to develop it.
    d. Action of the second grid as the oscillator plate; components in this grid circuit.
16. Describe the screen, suppressor-grid, and plate circuits.
17. State why only the i. f. passes through to the following stages, even though there are many frequencies present at the output of VT-150.

18. Point out the circuits used for the other bands in the heterodyne-oscillator stage and mention the variations from the band-6 circuit.

19. Point out key test point Ⓔ in the circuit and explain its use.

20. Point out the physical location of test point Ⓔ on the receiver.

CONCLUSIONS

The 1st-detector and heterodyne-oscillator stages function together to change the incoming r-f signal to an i-f signal. The 915-kc. output of the VT-150 is coupled to the i-f stages by means of a sharply tuned transformer. An inoperative condition of these stages can be detected by the use of one key test point.

ORAL QUIZ

1. What is the function of resistors 108-1 and 108-2 in parallel?

2. Why is it important that signals at or near 915 kc. be prevented from appearing in the injector-grid circuit? What measures are taken to eliminate such undesired signals?

3. What components in the 1st-detector stage are ganged to similar components in other stages? What are the other stages?

4. How is feedback secured to make oscillation possible in the tuned circuit of the heterodyne oscillator?

5. What is the difference in frequency between the incoming signal and the heterodyne-oscillator output on band-2 operation? On band-5 operation?

6. What method is used to keep the oscillator frequency 915 kc. away from the frequency of the incoming signal at all dial settings?

7. What was done in the design of this receiver to minimize the effect, on the heterodyne oscillator, of variations in voltage and temperature?

8. What is the purpose of the series padder capacitors in the tuned-grid circuits?

9. Why are the second and fourth grids in the VT-150 directly connected?

10. If a d-c voltmeter connected between the plate of VT-150 and ground indicates zero voltage, where is the fault probably located?

EXPERIMENT No. 4

TIME ALLOTTED: 1½ HR.

SUBJECT

1st-detector and heterodyne-oscillator stages.

OBJECTIVE

To become familiar with the methods used to check the alignment of, and to trouble-shoot, the 1st-detector and heterodyne-oscillator stages.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J (in good operating condition).
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-f signal generator (200 kc. to 18 mc.).
1 D-c voltmeter with 100-volt and 500-volt ranges (20,000-ohms-per-volt meter preferred).
1 Ohmmeter.
1 Output meter, rectifier type, 0—15 volts, 4000 ohms (contained in Test Set I-56-A and other Test Sets of the I-56 series).
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

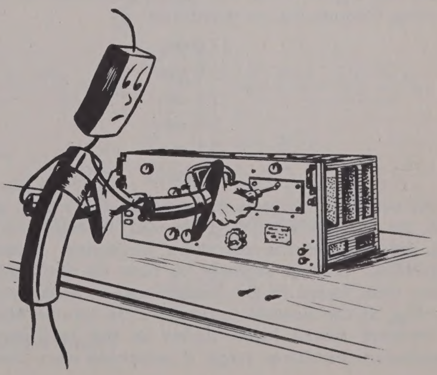
Remove the receiver chassis from the cabinet. Remove the small plate on the front panel. Connect the output meter to terminals 1 and 5 of the connector plug; set the meter for the 15-volt range. Connect the power source to the receiver. Plug headphones into the TEL. JACK. Connect the signal-generator output to the antenna post of the receiver through a 100-mmf. capacitor, and the signal-generator ground lead to the ground post of the receiver, using a short heavy lead.

PROCEDURE

1. Set the signal generator for a modulated output. Turn it on and adjust it for a weak signal. Set the receiver controls as follows:
   a. DIAL LIGHTS control fully clockwise.
   b. INCREASE VOL. control fully clockwise.
   c. C.W. OSC. switch to OFF.
   d. CRYSTAL switch to OUT.
   e. AVC-OFF-MVC switch to MVC.

Allow the receiver and signal generator to warm up for several minutes.

2. To check the alignment of the tuned circuits in the 1st-detector and heterodyne-oscillator stages, locate



the trimmer screws for these stages at the rear of the shielded units (DET. unit for 1st-detector stage, OSC. unit for the heterodyne-oscillator stage). Note that the padder-capacitor screw for band 1 in the oscillator stage is at the bottom of the OSC unit. With the signal generator connected to the receiver antenna post, tune the receiver and signal generator to 17.3 mc. Adjust the signal-generator output so that the output-meter reading is at approximately the center of the scale. With a screwdriver vary the trimmer screw for band 6 in the 1st-detector stage. Notice that the output reading changes as the screw is varied from its original setting, just as it did when the trimmer was adjusted in the experiment on the 1st r-f stage, and for the same reason; that is, there is a critical setting for the trimmer to produce proper alignment and maximum output. Reset the trimmer screw to its proper position as indicated by a maximum reading on the output meter.

3. Repeat the procedure in paragraph 2 for band 6 in the heterodyne-oscillator stage.

4. Tune the signal generator and receiver to 470 kc. and repeat the procedure in paragraph 2 for band 1 in the heterodyne-oscillator stage. Then tune the signal generator and receiver to 215 kc. and repeat the procedure once again for the low end of band 1, this time using the screw at the bottom of the OSC. unit marked OSC. PAD. This screw controls variable capacitor 4, the series padder for band 1. Two adjustments are used on band 1 in the heterodyne-oscillator stage to insure that this circuit is properly aligned at both ends of the band so that it will track properly, over the entire range, with the other circuits used in band-1 operation. This method is unnecessary on the other bands, since adequate tracking is achieved by the use of fixed series padders of a fairly critical value, in addition to the parallel trimmers. In all cases reset the trimmer screw to its proper position before proceeding to the next adjustment.

5. The over-all operation of the 1st-detector and heterodyne-oscillator stages can be checked by introducing a modulated r-f signal at key test point E and listening to the receiver output. Connect the signal generator to test point E, which is located in the opening behind the small removable plate on the front panel. It is at the 1st-detector section of the ganged tuning capacitor, which is the third section from the right. Tune the signal generator to the following frequencies, in succession;

17.0 mc.
13.0 mc.
9.0 mc.
5.0 mc.
3.0 mc.
400 kc.

As each frequency is tuned in on the signal generator, set the BAND SWITCH and TUNING controls on the receiver for the same frequency. Rotate the TUNING control slightly to tune in the signal. A clear tone, heard in the headphones at each frequency setting, is the normal indication. In trouble-shooting a receiver which has a defect in the 1st-detector or heterodyne-oscillator stage, if reception were abnormal for some bands, but not for all bands, the fault would be in the switches, coils or other components involved in the bands for which abnormal indication is obtained, or in the alignment of those bands. If there were no reception on any band, the fault would probably be in the 1st-detector and heterodyne-oscillator tube (VT-150), or in associated components which are used for operation on all bands.

6. Set the receiver controls as follows:

a. BAND SWITCH and TUNING set for 200 kc.
b. CRYSTAL switch to OUT.
c. C.W.OSC. switch to OFF.
d. INCREASE VOL. control fully clockwise.
e. DIAL LIGHTS control fully clockwise.
f. AVC-OFF-MVC switch to MVC.
g. Headphones and signal generator disconnected from the receiver.

Using the d-c voltmeter, take voltage readings between all of the socket terminals of VT-150 and ground. CAUTION! HIGH VOLTAGE! Draw up a chart showing the voltage between each socket terminal and ground, and indicate the tube element which is being checked at each terminal. Read the screen and plate voltages on the 500-volt scale.

7. Disconnect the power plug. Leave the receiver controls in the same positions. Using the ohmmeter, make resistance readings between all of the socket terminals of VT-150 and ground. Draw up a chart showing the resistance between each socket terminal and ground, and indicate the tube element which is being checked at each terminal.

8. Request the instructor to place a defect in the 1st detector or heterodyne oscillator stage. By making use of key test point E, make certain that there is a defect present; then, by means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

9. Request the instructor to place another defect in the 1st detector or oscillator stage. By making use of key test point E, make certain that there is a defect present; then, by means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

10. Restore the receiver to its original condition.

CONCLUSIONS

1. Why are there two variable capacitor adjustments for band 1 in the heterodyne-oscillator stage?

2. If the strength of the signal from the signal generator is kept constant, will it produce a stronger or weaker receiver output signal when using test point E, than when using test point F1? Why?

3. If the d-c voltage reading between the fourth grid of VT-150 (socket terminal number 4) and ground is zero volts, what component is probably at fault?

4. What would be the effect on the receiver if capacitor 12 in the band-6 circuit of the heterodyne-oscillator stage had a capacitance of 370 mmf?

5. What are several possible causes of a zero d-c voltage reading between socket terminal number 8 of VT-150 and ground, on all bands?

LECTURE No. 6

CIRCUIT ANALYSIS OF THE 1ST, 2ND, AND 3RD I-F STAGES

The three i-f stages provide a high degree of selectivity and additional amplification, which are easier to secure at the intermediate frequency (915 kc.) than at radio frequencies ranging up to 18 mc. By utilizing an i.f. it is possible to design the i-f circuits so that they provide uniform selectivity and amplification at all settings of the tuning dial. The 1st and 2nd i-f stages employ the same type of tube, VT-117 (6SK7), used in the 1st and 2nd r-f stages; this type of tube is a remote cut-off amplifier suitable for use with a.v.c. The 3rd i-f stage, which is not connected to the a-v-c circuit, uses a VT-116 (6SJ7), a sharp cut-off pentode amplifier that has a high amplification factor. These stages are shown in block form on Wall Chart No. 1 and in schematic form on Wall Chart No. 2.

1ST I-F STAGE

The high degree of selectivity provided by the i-f stages results mainly from the use of three i-f transformers. The 1st i-f transformer (147) couples the output circuit of VT-150 to the 1st i-f amplifier grid (see the schematic diagram in figure 10). The transformer is double-tuned, with fixed capacitor 15-2 in parallel with the primary and fixed capacitor 15-3 in parallel with the secondary. These relatively large capacitors provide a low tuned-circuit impedance, resulting in an inherently stable amplifier. The transformer can be adjusted to the proper frequency in the shop, if it drifts out of alignment, by moving the adjustable iron core around which each coil is wound; the screws which adjust these cores are at the top and bottom of each coil can (see figure 7). The increased permeability which results from the use of iron cores contributes to the highly selective characteristics of the transformer. The i-f transformer, with its associated fixed capacitors, is contained in a separate shielded can on the top of the chassis.

The 1st i-f stage is designed to operate as a relatively low-gain stage (when compared to the 3rd i-f stage), with the emphasis on selectivity rather than amplification. The control grid of the 1st i-f amplifier tube is connected to the a-v-c circuit through the secondary coil of transformer 147, and thus the gain of the tube is controlled by the a-v-c voltage on a-v-c operation. Resistor 113 is the cathode-bias resistor for this tube and, like the cathode resistor in the 1st and 2nd r-f stages, it is in the manual-volume-control circuit; it is connected to a voltage divider consisting of resistor 94-2 and the 20,000 ohm potentiometer section of resistor 110. Thus, the gain of the stage on m-v-c operation is controlled by the INCREASE VOL. control, which actuates resistor 110.

The proper screen-grid voltage for the 1st i-f amplifier tube is secured by connecting the screen to a voltage divider, consisting of resistors 87-4 and 97-2, which are connected from the high-voltage bus to ground. The connection to the high-voltage bus is made through the connector plug, and through the transmitter relay if the receiver is used with a transmitter. Capacitor 61-3 provides a by-pass to ground for r-f.

The suppressor grid of this tube is connected directly to the cathode. The plate is connected to the high-voltage line through plate-load resistor 101-1, across which the signal voltage is developed; it also drops the d-c plate voltage to the proper level. Capaci-

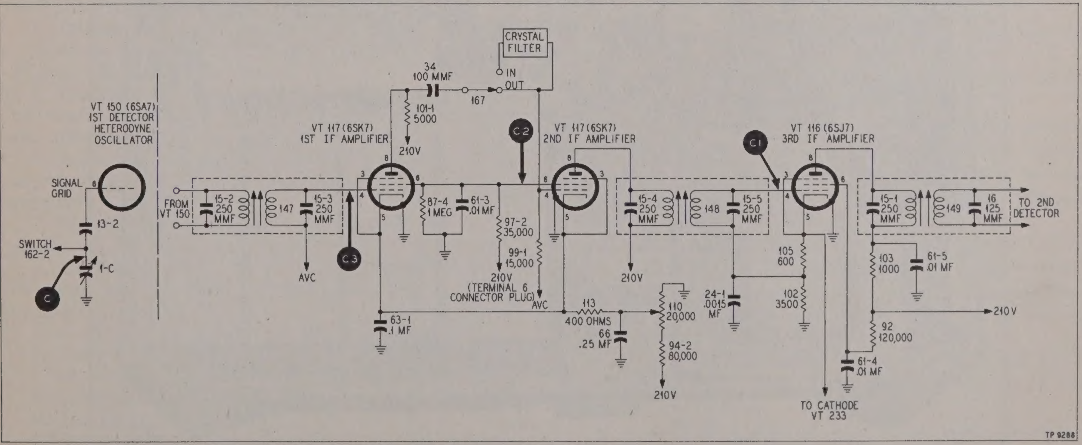

CRYSTAL FILTER
IN
OUT
34
100 MMF
167
101-1
5000
210V
VT 150 (6SA7)
1ST DETECTOR
HETERODYNE
OSCILLATOR
SIGNAL GRID
13-2
SWITCH 162-2
1-C
C
FROM VT 150
15-2
250 MMF
147
15-3
250 MMF
AVC
C3
VT 117 (6SK7)
1ST IF AMPLIFIER
87-4
1 MEG
61-3
.01 MF
97-2
35,000
99-1
15,000
210V
(TERMINAL 6
CONNECTOR PLUG)
AVC
63-1
.1 MF
C2
VT 117 (6SK7)
2ND IF AMPLIFIER
15-4
250 MMF
148
15-5
250 MMF
210V
113
400 OHMS
66
.25 MF
110
20,000
94-2
80,000
210V
24-1
.0015 MF
C1
VT 116 (6SJ7)
3RD IF AMPLIFIER
105
600
102
3500
TO CATHODE
VT 233
15-1
250 MMF
149
16
125 MMF
TO 2ND DETECTOR
103
1000
61-5
.01 MF
210V
92
120,000
61-4
.01 MF
TP 9288

Figure 10. 1st, 2nd, and 3rd I-F Amplifier Circuits

tor 34 is a d-c blocking capacitor between the 1st i-f amplifier plate circuit and the following stage, which is either the crystal filter or the 2nd i-f stage, depending upon the position of the CRYSTAL switch (167). For the purposes of this lesson, it is assumed that the switch is in the OUT position, and the crystal filter and associated components are disregarded.

2ND I-F STAGE

With the CRYSTAL switch in the OUT position, the 1st i-f plate circuit is connected to the 2nd i-f control grid through the d-c blocking capacitor. The 2nd i-f stage, like the 1st i-f stage, is designed for relatively low gain. The control grid is connected to the a-v-c circuit through grid resistor 99-1, across which the signal voltage is developed. Several components are used by this stage in common with the 1st i-f stage. Cathode resistor 113, which is in the m-v-c circuit, is used by both stages. Also, the common voltage divider consisting of resistors 87-4 and 97-2 is connected to the screen grids of both tubes.

The suppressor grid of the 2nd i-f amplifier tube is connected directly to the cathode. The plate is connected to the high-voltage bus by means of the primary coil of the 2nd i-f transformer (148). This transformer, which is similar in design and function to the 1st i-f transformer, couples the output circuit of the 2nd i-f stage to the grid of the 3rd i-f amplifier tube.

3RD I-F STAGE

The 3rd i-f stage is designed to function as a high-gain stage. The VT-116 has a high amplification factor, and its gain is not controlled by either the a-v-c or m-v-c circuit. The advantage of providing much of the i-f gain in this stage is that there are few unwanted signals at this point in the circuit.

The primary of transformer 148 is paralleled by capacitor 15-4, and the secondary is paralleled by capacitor 15-5. Cathode bias for VT-116, the 3rd i-f amplifier tube, is developed across resistor 102; resistor 105 provides a certain amount of degenerative action to keep the tube from overloading, which is necessary because the gain is not controlled in any other way. The cathode of VT-116 is connected to the cathode of VT-233, in order that resistors 102 and 105 may provide a delaying action in connection with the a-v-c circuit. Capacitor 24-1 provides an r-f path to ground.

The suppressor grid of VT-116 is connected directly to the cathode. The screen grid is connected to the 210-volt bus through resistor 92, which drops the voltage to the proper amount; capacitor 61-4 provides a low-impedance r-f path to ground. The plate is connected to the high-voltage bus through the primary coil of i-f transformer 149. Resistor 103 and capacitor 61-5 act as the plate-supply filter circuit.

The 3rd i-f amplifier plate is coupled to the 2nd-detector diode by means of the 3rd i-f transformer (149), which is similar in design and function to the other i-f transformers. The primary coil is tuned by fixed capacitor 15-1; fixed capacitor 16 parallels the secondary coil. Capacitor 16 has a value of only 125 mmf., in contrast to the other capacitors in parallel with each i-f coil, which have a capacitance of 250 mmf. However, the lowered capacitance in this circuit is compensated for by the input impedance of the detector diode section of VT-233. At this point in the receiver, there are very few unwanted signals; the selected signal has been suitably amplified, and will be passed on to the 2nd-detector stage, where the i-f component will be eliminated.

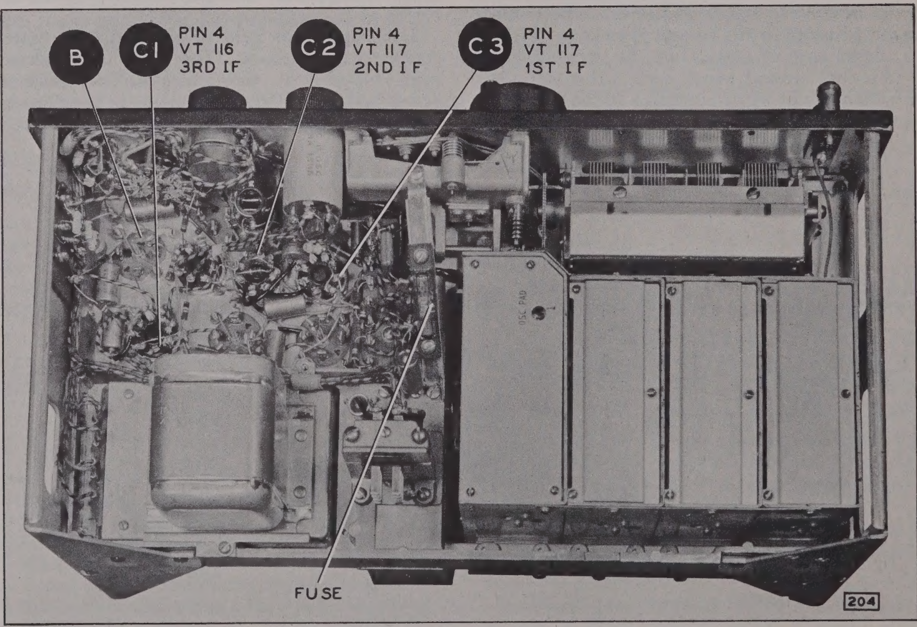


Figure 11. Location of Test Points B, C1, C2, and C3

Key test point C is used to check the over-all operation of the three i-f stages. This test point is at the same location as test point E, which is used to check the 1st-detector and heterodyne-oscillator stages; that is, at the 1st-detector section of the ganged tuning capacitor (see figure 8). After the circuits following the i-f stages have been cleared of trouble by the use of a trouble-shooting procedure, the operation of the i-f stages is checked by connecting a modulated signal generator (tuned to 915 kc.) between test point C and ground and listening in the headphones. The normal indication is a clear tone. Trouble may be isolated to a particular stage by use of secondary test points C1, C2, and C3, which are located at the control grids of the 3rd, 2nd, and 1st i-f amplifier tubes, respectively, and by making use of key test point C as a secondary test point. Test points C1, C2, and C3 are physically located at the appropriate tube-socket terminals on the underside of the chassis (see figure 11).

LESSON PLAN No. 6

TIME ALLOTTED: 1¼ HR.

SUBJECT

Circuit analysis of the 1st, 2nd, and 3rd i-f stages.

OBJECTIVE

To analyze the i-f circuits.

INTRODUCTION

In order to secure high selectivity and a constant amount of amplification at all incoming frequencies, this receiver converts the r-f signal to an i-f signal, which is amplified by three i-f stages.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram) and briefly review the action of the i-f circuits.
2. Display Wall Chart No. 2 (schematic diagram) and point out the i-f circuits.
3. Discuss the types of tubes used in the i-f stages.
4. Draw the schematic diagram of the 1st i-f stage (figure 10) on the blackboard.
5. Discuss the design and function of transformer 147 and its associated fixed capacitors, and point out the advantages resulting from this design.
6. Indicate the location, on the receiver, of the screws which vary the transformer cores for alignment purposes.
7. Mention the low-gain operation of the 1st i-f stage.
8. Explain in detail the following items in the 1st i-f stage and identify the components by reference symbols:
   a. A-v-c circuit connection to the control grid.
   b. Cathode-bias resistor, and its connection to the m-v-c circuit.
   c. Screen-grid and plate circuits.
   d. Use of switch 167.
9. Draw the schematic diagram of the 2nd i-f stage (figure 10) on the blackboard, showing the connections to the 1st i-f stage.
10. Mention the low-gain operation of the 2nd i-f stage.
11. Explain in detail the following items in the 2nd i-f stage and identify the components by reference symbols:
   a. A-v-c circuit connection to the control grid.
   b. Use of common components in the cathode and screen-grid circuits.
   c. Plate circuit and the use of the 2nd i-f transformer.
12. Draw the schematic diagram of the 3rd i-f stage (figure 10) on the blackboard, showing the connections to the 2nd i-f stage.
13. Discuss the high-gain operation of the 3rd i-f stage.
14. Explain in detail the following items in the 3rd i-f stage and identify the components by reference symbols:
   a. 2nd i-f transformer (148) and associated capacitors.
   b. Biasing and regenerative circuit.
   c. Use of resistors 102 and 105 in connection with the a-v-c circuit.
   d. Screen and plate circuit components; suppressor-grid connection.
   e. 3rd i-f transformer (149) and associated capacitors; explain why the parallel capacitor in the secondary (16) is only 125 mmf.
15. Discuss the characteristics of the signals at the output of the 3rd i-f stage.
16. Point out key test point C and secondary test points C1, C2, and C3 in the circuit and explain their use.
17. Point out the physical location of these test points on the receiver.

CONCLUSIONS

An inoperative condition of the i-f stages may be detected by the use of one key test point. Trouble may be isolated to a particular i-f stage by the use of three secondary test points.

ORAL QUIZ

1. What types of tubes are used in the three i-f stages?
2. What advantages are secured by the use of an intermediate frequency?
3. What is the reason for using tubes with a remote cut-off characteristic in the 1st and 2nd i-f stages?
4. How can the i-f transformers be tuned to the proper frequency? Why is it important that they all be tuned to the same frequency?
5. When is cathode bias used for the 1st and 2nd i-f stages? What type of bias is used for a-v-c operation?
6. Why is it more suitable for the 3rd i-f amplifier tube to provide high gain, rather than the 1st or 2nd i-f amplifier tube?
7. If the CRYSTAL switch (167) is in the OUT position, to which stage is the output of the 1st i-f amplifier tube coupled?
8. If there is an abnormal indication when the signal generator is used at test point C2, in which stage is the trouble probably located?

EXPERIMENT No. 5

TIME ALLOTTED: 2½ HR.

SUBJECT

1st, 2nd, and 3rd i-f stages.

OBJECTIVE

To become familiar with the methods used to check the alignment of, and to trouble-shoot, the i-f stages.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J (in good operating condition).
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-f signal generator (200 kc. to 18 mc.).
1 D-c voltmeter with 100-volt and 500-volt ranges (20,000-ohms-per-volt meter preferred).
1 Ohmmeter.
1 Output meter, rectifier type, 0—15 volts, 4000 ohms (contained in Test Set I-56-A and other Test Sets of the I-56 series).
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Remove the small plate on the front panel. Connect the output meter to terminals 1 and 5 of the connector plug; set the meter for the 15-volt range. Connect the power source to the receiver. Plug the headphones into the TEL. JACK. Connect the signal-generator ground lead to the ground post of the receiver, using a short heavy lead.

PROCEDURE

1. Set the signal generator for a modulated output at 915 kc. To check the alignment of the i-f transformers, the signal is injected at the signal grid of VT-150, the 1st-detector, heterodyne-oscillator tube. This grid is connected to an external terminal which is at the front of the shielded OSC. unit and available from the top of the chassis; this terminal is the second one from the top in the right-hand row. Connect the signal-generator output to the terminal through a 1-mf. capacitor; turn on the generator and adjust it for a weak signal. Set the receiver controls as follows:
   a. DIAL LIGHTS control fully clockwise.
   b. INCREASE VOL. control fully clockwise.
   c. C. W. OSC. switch to OFF.
   d. CRYSTAL switch to OUT.
   e. AVC-OFF-MVC switch to MVC.
   f. BAND SWITCH and TUNING set for 1.5 mc. Allow the receiver and signal generator to warm up for several minutes.

2. Locate the screws which move the iron cores in and out of the primary and secondary windings of the 3rd i-f transformer. The secondary adjustment screw is located at the opening in the top of the shielded container, and the primary adjustment screw is located at the bottom of the coil assembly, on the underside of the chassis. To check the alignment of the 3rd i-f transformer, adjust the signal-generator output so that the output meter produces a reading at approximately the center of its scale. Vary the top screw (secondary) and notice that the reading on the output meter also changes. This adjustment moves the iron core in and out of the coil, thus varying the inductance of the circuit and tuning it. Now vary the bottom screw (primary) and notice the effect on the output meter. The meter indicates that there is a critical setting for the screws for maximum output, which occurs when the two circuits, of which the coils are a part, are tuned to 915 kc. and thus aligned with the other i-f transformers. Align the transformer by varying the two screws for maximum output, adjusting the top screw first and then the bottom screw. Repeat this several times for the maximum reading on the output meter.

3. Locate the screws which adjust the iron cores in the 2nd i-f transformer. Check the alignment of the transformer, repeating the procedure outlined in paragraph 2. Be sure to realign the 2nd i-f transformer for maximum output before proceeding to the next alignment check.

4. Locate the screws which adjust the iron cores in the 1st i-f transformer. Check the alignment of the transformer, repeating the procedure outlined in paragraph 2. Be sure to realign the 1st i-f transformer for maximum output before proceeding to the next step in the experiment.

5. The over-all operation of the i-f stages can be checked by introducing a modulated signal of 915 kc. at key test point (C), and listening to the receiver output. Key test point (C) is located at the same place as key test point (E), which has already been used to check the 1st-detector and heterodyne-oscillator stages; that is, it is at the 1st-detector section of the ganged tuning capacitor, which is the third section from the right, in the opening behind the small removable plate on the front panel. Connect the signal-generator output to the test point; leave the generator controls in the positions they are already in, but set the BAND SWITCH on the receiver to the 200—500 kc. band, and turn the CRYSTAL switch to ON. A clear tone, heard in the headphones, is the normal indication. If this were a receiver with a defect in the i-f stages, the indication when using this key test point would be abnormal, and the secondary test points would be used to isolate the trouble to one of the stages.

6. Locate secondary test point (C1) at the grid of the 3rd i-f amplifier tube (socket terminal 4), on the underside of the chassis. Connect the signal-generator output to this test point, and set it for medium output. A clear tone will be heard in the headphones; this is the normal indication. If this were a defective set and there were an abnormal indication when using this test point, the trouble would be in the 3rd i-f amplifier tube (VT-116) or associated components, capacitor 61-4, 61-5, or 24-1, or in transformer 148 or 149 (including misalignment of transformer 149).

7. Locate secondary test point C2 at the grid of the 2nd i-f amplifier tube (socket terminal 4), on the underside of the chassis. Connect the signal-generator output to this test point, leaving the output setting as before. A clear tone, louder than when using test point C1, is the normal indication. If this were a defective set and there were an abnormal indication when using this test point, the trouble would be in the 2nd i-f amplifier tube (VT-117) or associated components, or transformer 148 (including misalignment).

8. Locate secondary test point C3 at the grid of the 1st i-f amplifier tube (socket terminal 4), on the underside on the chassis. In order to reach this terminal, it is necessary to remove the metal shield covering the tube socket. CAUTION! Turn the AVC-OFF-MVC switch to OFF before removing the shield. When the shield is removed, turn the switch back to MVC. Connect the signal-generator output to the test point, leaving the output setting as before. A clear tone, louder than when using test point C2, is the normal indication. If this were a defective set and there were an abnormal indication when using test point C3, the trouble would be in the 1st i-f amplifier tube (VT-117) or associated components, or transformer 147. This test point also checks the crystal (160) and crystal neutralizing coil, which will be discussed in the next lesson.

9. If the use of key test point C were to produce an abnormal indication, in trouble-shooting a defective receiver, and the use of secondary test points C1, C2, and C3 produced normal indications, the trouble would be located between test point C and test point C3. If it were necessary to check this portion of the circuit, key test point C could be used as a secondary test point, and the procedure given in paragraph 5 would be repeated. An abnormal indication when using this test point would mean that the trouble was located in the 1st-detector, heterodyne-oscillator tube (VT-150) or its associated components, including capacitor 60. and transformer 147.

10. Set the receiver controls as follows:

a. BAND SWITCH and TUNING set for 200 kc.
b. CRYSTAL switch to OUT.
c. C. W. OSC. switch to OFF.
d. INCREASE VOL. control fully clockwise.
e. DIAL LIGHTS control fully clockwise.
f. AVC-OFF-MVC switch to MVC.
g. Headphones and signal generator disconnected from the receiver.

Using the d-c voltmeter take voltage readings between all of the socket terminals of the three i-f tubes and ground. CAUTION! HIGH VOLTAGE! Draw up a chart showing the voltage between each terminal and ground, and indicate the tube element which is being checked at each terminal. Read screen-grid and plate voltages on the 500-volt scale.

11. Disconnect the power plug. Leave the receiver controls in the same position. Using the ohmmeter, make resistance readings between all of the socket terminals and ground. Draw up a chart showing the resistance between each terminal and ground, and indicate the tube element which is being checked at each terminal. Readings at terminal 4 of the 1st and 2nd i-f tubes should be made on both the MVC and AVC positions of the AVC-OFF-MVC switch. All other readings are made on the MVC position only.

12. Request the instructor to place a defect in one of the i-f stages. By making use of test points, visual inspection, and voltage or resistance measurements, as required, locate the defect and correct it.

13. Request the instructor to place another defect in the i-f stages. By making use of test points, visual inspection, and voltage or resistance measurements, as required, locate the defect and correct it.

14. Restore the receiver to its original condition.

CONCLUSIONS

1. Why is the output signal stronger when test point C2 is used than when test point C1 is used, for the same strength input signal?

2. Why is it necessary to adjust the cores of both the primary and secondary coils of an i-f transformer at the same time?

3. If the d-c voltage between socket terminal 6 of the 1st i-f amplifier tube and ground is 175 volts, which components may be at fault?

4. Name the faulty component if there is a 50-ohm resistance between socket terminal 5 of the 2nd i-f amplifier tube and ground.

5. What would be the effect on the receiver if capacitor 15-3 in the 1st i-f stage were shorted?

LECTURE No. 7

CIRCUIT ANALYSIS OF THE CRYSTAL-FILTER CIRCUIT

The crystal filter increases the selectivity of the receiver, when desired, passing on signals at or near 915 kc., and eliminating other signals which have been passed by prior circuits. This circuit is shown in block form on Wall Chart No. 1 and in schematic form on Wall Chart No. 2.

The crystal filter is switched in and out of the circuit between the 1st and 2nd i-f stages by means of switch 167, which is operated from the front panel. The filter consists principally of a 915-kc. crystal (160), an autotransformer (150) known as the neutralizing coil, and a neutralizing capacitor, which consists of two wires and two lugs extending from the autotransformer (see figure 12). The capacitance of the crystal holder must also be considered as part of the circuit.

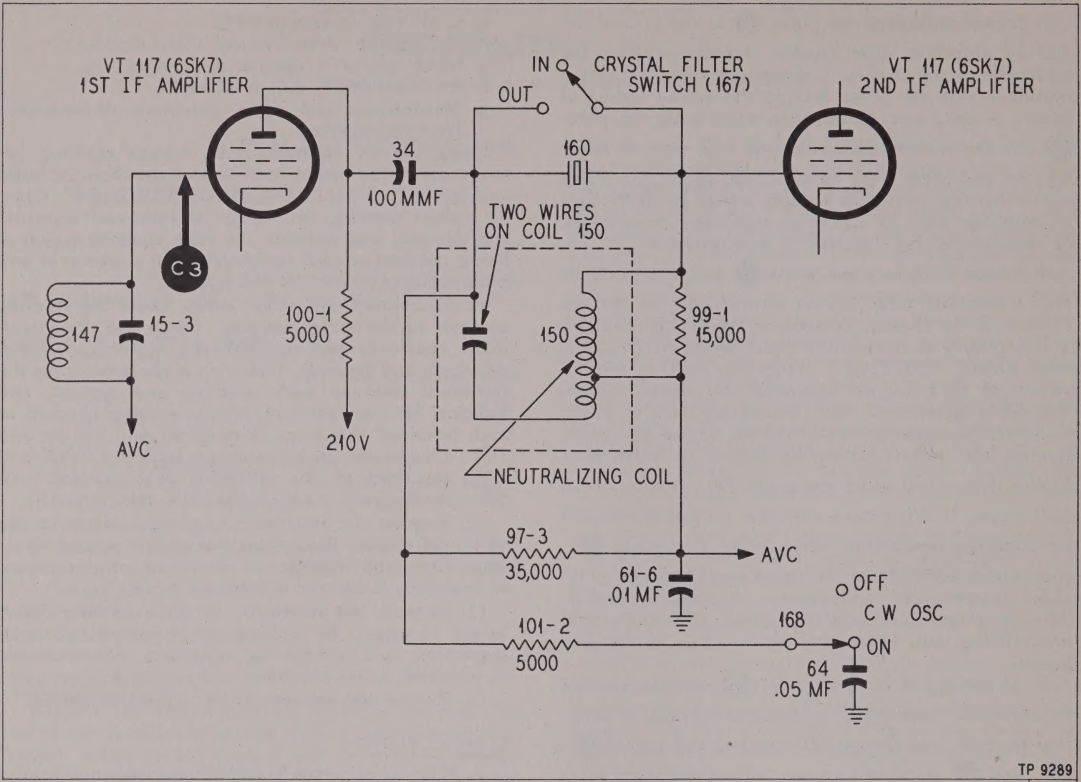


Figure 12. Crystal-Filter Circuit

When the filter is in the circuit, it functions as follows: For signals at or very near 915 kc., the crystal acts as a series-resonant circuit, and offers minimum impedance. The signal voltage is thus developed across grid resistor 99-1, and is applied to the grid of the 2nd i-f amplifier tube. It might seem that signals of other frequencies would be stopped because of the high impedance offered by the crystal, since it has a very narrow band-pass. However, some unwanted signals may be by-passed around the crystal because the crystal holder acts as a capacitor (with the crystal acting as a dielectric). These unwanted signals are neutralized or balanced out by means of the neutralizing coil and capacitor. The signal which is by-passed around the crystal develops a voltage across the section of the coil which is connected between the grid of the 2nd i-f amplifier tube and ground (through a-v-c filter capacitor 61-6). An opposing voltage is developed across the other section of the neutralizing coil (which is connected to the input side of the crystal through the neutralizing capacitor); the neutralizing capacitor aids by making the opposing voltage exactly opposite in phase to the unwanted signal voltage, which is thus cancelled or balanced out.

Capacitor 34 couples the 1st i-f amplifier tube to the filter circuit. Resistor 97-3 is shunted across the neutralizing capacitor and part of the neutralizing coil, and aids in suppressing receiver noise. Resistor 101-2 and capacitor 64 are switched into the circuit when the C.W. OSC. switch (168) is turned to ON. These components provide a path to ground for the i-f signals, thus reducing the gain of the 1st i-f tube and preventing overloading of the 3rd i-f tube, to which the c-w oscillator output is fed. Capacitor 64 also provides filtering action in connection with the a-v-c circuit on c-w operation. The a-v-c circuit is connected to the grid of the 2nd i-f tube through grid resistor 99-1, which is shunted across one section of the autotransformer.

The neutralizing coil and capacitor are contained in one shielded unit and are replaceable as a unit. The filter can be adjusted to achieve the proper balance by manipulating the two wires which constitute the neutralizing capacitor. However, this adjustment is very rarely necessary, and is usually made only when the crystal, switch assembly (167), or the neutralizing coil are replaced.

As mentioned in the experiment on trouble-shooting the i-f stages, test point C3 checks the components in the crystal-filter circuit. That is, if an abnormal indication is received when secondary test point C3 is used, the trouble lies in the components of the 1st i-f stage, or in the crystal or neutralizing coil. Visual inspection or voltage and resistance measurements, as required, will locate the component at fault.

LESSON PLAN No. 8

TIME ALLOTTED: ½ HR.

SUBJECT

Circuit analysis of the crystal-filter circuit.

OBJECTIVE

To analyze the crystal-filter circuit.

INTRODUCTION

The crystal filter provides a method for increasing the selectivity of the receiver when desired, as in cases of heavy interference. Only a narrow band of frequencies near 915 kc. is allowed to pass, due to the action of a crystal and a neutralizing circuit.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram) and briefly review the action of the crystal filter.
2. Display Wall Chart No. 2 (schematic diagram) and point out the crystal-filter circuit.
3. Draw the schematic diagram of the crystal filter (figure 12) on the blackboard.
4. Point out and identify by reference symbols the components making up the crystal-filter circuit.
5. Explain in detail the action of the crystal-filter circuit, emphasizing the following items:
    a. Why i-f signals pass through the crystal circuit.
    b. Why other signals are blocked by the crystal.
    c. Action of crystal-holder capacitance.
    d. How unwanted signals, passed because of crystal-holder capacitance, are neutralized.
6. Point out the following components and explain their purpose: capacitor 34, resistor 97-3, resistor 101-2 and capacitor 64, and resistor 99-1.
7. Discuss the construction of the neutralizing coil and capacitor, and the method of balancing the filter circuit.
8. Review the use of secondary test point C3 in connection with the crystal-filter circuit.

CONCLUSIONS

Although there is no test point which can directly check the operation of the crystal-filter circuit, an abnormal indication at one secondary test point may indicate trouble in this circuit.

ORAL QUIZ

1. Under what conditions would you expect to use the crystal filter? Why?
2. Of what significance is the bandwidth of the crystal-filter circuit?
3. Why must consideration be given to the capacitance of the crystal holder?
4. Which components are principally responsible for the neutralizing process? What is their action?
5. Is it necessary to adjust the crystal-filter circuit frequently to achieve proper balance?
6. If neutralizing coil 150 is defective, what test point will isolate the circuit in which it is located?

REVIEW No. 1

Display Wall Charts No. 1 and No. 2 and review the important points contained in Lectures No. 1 through No. 7 and Experiments No. 1 through No. 5, by orally interrogating the students. The normal time allotment for this review is three hours.

Beginning with Lesson Plan No. 1, state each question contained in the Oral Quiz section of each Lesson Plan and in the Conclusions section of each Experiment. Explain fully the answers to those questions which cause the students difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. Make a written note of each question on which the students indicate a general weakness.

EXAMINATION No. 1

Examination No. 1 covers the material contained in Lectures No. 1 through No. 7 and Experiments No. 1 through No. 5. The normal time allotment for this examination is two hours. Do not permit the students to refer to any material while answering the questions in Part I of the examination. Display both Wall Charts before presenting Part II, and permit the students to refer to the schematic diagram.

Part I

1. Draw the functional block diagram of Radio Receiver BC-348-J.

2. What provision is made, in a typical installation of this receiver, to reduce the effects of vibration?

3. What input voltage is required for the operation of the dynamotor? What are the positive and negative voltages supplied by the dynamotor?

4. What is the frequency range of the receiver? How many bands are used to cover this range?

5. What are the three functions of the connector plug?

6. Name the control which turns the receiver on and off. What are the positions of this switch used for?

7. What two components are mechanically varied when the TUNING control is used?

8. By what means is the receiver cabinet fastened to the chassis? To the mounting?

9. Under what conditions would it be an aid to turn the CRYSTAL switch to the IN position?

10. Which ganged components are operated by the use of the BAND SWITCH?

11. Name the two controls which are mainly associated with c-w reception. What are the functions of these controls?

12. What are the two principal functions of the r-f stages?

13. If the receiver is tuned to the frequency of an incoming c-w signal, and the C.W. OSC. switch is in the OFF position, what will be heard in the headphones?

14. At what points in the receiver is the audio output made easily available?

15. What is the function of the a-v-c circuit? Give a short description of how the circuit works.

16. What does major test point 1 check? What does major test point 2 check? What is the circuit location of these test points?

17. What is the electrical effect on the selected tuned circuits in the r-f and 1st-detector stages when the TUNING control is varied?

18. To which stage is the output of the 1st i-f amplifier tube coupled when the CRYSTAL switch is in the OUT position?

19. When the receiver is tuned to receive a 250-kc. signal, what is the frequency at which the heterodyne oscillator is operating?

20. What is the reason for having a neutralizing coil and capacitor in the crystal-filter circuit?

Part II

1. If reception on band 4 is abnormal, but reception on all other bands is normal, in which of the following functional blocks would you be most likely to find the trouble?
   a. 2nd i-f.
   b. Audio amplifier.
   c. 1st r-f.
   d. C-w oscillator.

2. Resistor 99-3 in the 1st r-f stage opens. What is the probable result?
   a. Grid bias on the 1st r-f tube increases.
   b. Abnormal operation on band 6 only.
   c. Screen voltage of the 1st r-f tube increases.
   d. Plate voltage of the 1st r-f tube drops to zero.

3. The cathode winding of coil assembly 142 in the heterodyne-oscillator stage opens. What is the trouble symptom?
   a. No headphone indication on band-5 operation.
   b. Receiver sensitivity decreases on all bands.
   c. Oscillator will not function on any band.
   d. Oscillator frequency increases on band-5 operation.

4. Screen by-pass capacitor 60 in the heterodyne-oscillator stage is shorted. What is the trouble symptom?
   a. Increase in the heterodyne-oscillator frequency.
   b. Decrease in the heterodyne-oscillator frequency.
   c. Zero voltage reading between terminal 4 of VT-150 and ground.
   d. No d-c voltage between the signal grid and ground.

5. If the primary coil of transformer 148 is open, what test point will isolate the particular circuit in which the trouble is located?
   a. D.
   b. C.
   c. C2.
   d. C1.

6. The crystal neutralizing capacitor is not properly adjusted. What is the probable result?
   a. Set is inoperative when switch 167 is turned to IN.
   b. No improvement in selectivity when the CRYSTAL switch is turned to IN.
   c. A-v-c voltage shorted out of the circuit.

7. What is the likely cause of a zero-resistance measurement between socket terminal 3 of the 1st i-f tube (VT-117) and ground?
   a. Shorted capacitor 66.
   b. Open resistor 113.
   c. Shorted capacitor 63-1.

8. What is the circuit location of the test point which checks the operation of the heterodyne oscillator?
   a. Antenna post.
   b. Ungrounded side of capacitor 1-C.
   c. Ungrounded side of capacitor 1-B.
   d. Control grid of the 1st i-f amplifier.

9. The use of test point C1 produces an abnormal indication. What is the next step in the trouble-shooting procedure?
   a. Use test point C2 in the 2nd i-f stage.
   b. Make voltage and resistance measurements between the socket terminals of VT-116 and ground.
   c. Use test point C at the 1st-detector tuning capacitor.

10. With the AVC-OFF-MVC switch (169) in the AVC position and the INCREASE VOL. control turned fully clockwise, the resistance measurement between socket terminal 5 of the 2nd r-f tube and ground is zero. What is the defective component?
   a. Shorted resistor 106.
   b. Shorted capacitor 66.
   c. Open resistor 110.
   d. Shorted resistor 107-3.

REVIEW OF EXAMINATION No. 1

Display Wall Charts No. 1 and No. 2 and review, orally, the questions on Examination No. 1. The normal time allotment for this review is one hour.

State each question contained in Examination No. 1, in turn. Fully explain the answers to those questions which cause the students difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. Make a written note of each question on which the students indicate a general weakness.

LECTURE No. 8

CIRCUIT ANALYSIS OF THE 2ND-DETECTOR STAGE AND A-V-C CIRCUIT

The 2nd-detector and a-v-c circuits both employ the VT-233 (6SR7), a duplex diode-triode. The c-w oscillator stage utilizes the triode section of this tube. The 2nd-detector circuit uses one of the two diodes in the tube (socket terminal 4); this circuit detects the signal fed to it from the 3rd i-f stage, and passes on to the audio stage only the audio component of the signal. The a-v-c circuit uses the other diode in the tube (socket terminal 5); when desired, this circuit automatically keeps the audio output at the level selected by the operator. These circuits are shown in block form on Wall Chart No. 1 and in schematic form on Wall Chart No. 2.

2ND DETECTOR

The detector diode is coupled to the 3rd i-f stage by means of the 3rd i-f transformer (see figure 13). A relatively high-level signal is supplied to the diode, which is advantageous, because the detected output is such that only one stage of audio amplification is necessary. The high-level detection also results in minimizing the effect of the characteristic curvature at the lower end of the diode curve. The over-all distortion caused by this part of the curve is relatively small because a much larger portion of the linear section of the curve is utilized. The cathode is kept at a higher potential than the detector diode plate by means of the voltage developed by the current flow through the 350,000-ohm section of resistor 110.

The detector circuit functions in a normal manner, detecting the incoming amplified i-f signal and placing an audio voltage across the 350,000-ohm section of the two-section resistor 110, which is connected to the grid circuit of the audio-amplifier tube. When the AVC-OFF-MVC switch is in the AVC position, the 350,000-ohm section of resistor 110 is connected as a potentiometer; it is varied by the INCREASE VOL. control on the front panel, which determines the audio level, depending on the setting of the tap on the potentiometer. When manual volume control is used, the entire 350,000-ohm section of the resistor is in the circuit, and the volume is controlled by the 20,000-ohm potentiometer section of resistor 110, which is connected to the cathode circuits of the 1st and 2nd r-f and 1st and 2nd i-f stages. The volume control methods will be discussed more fully in the a-v-c section of this lecture.

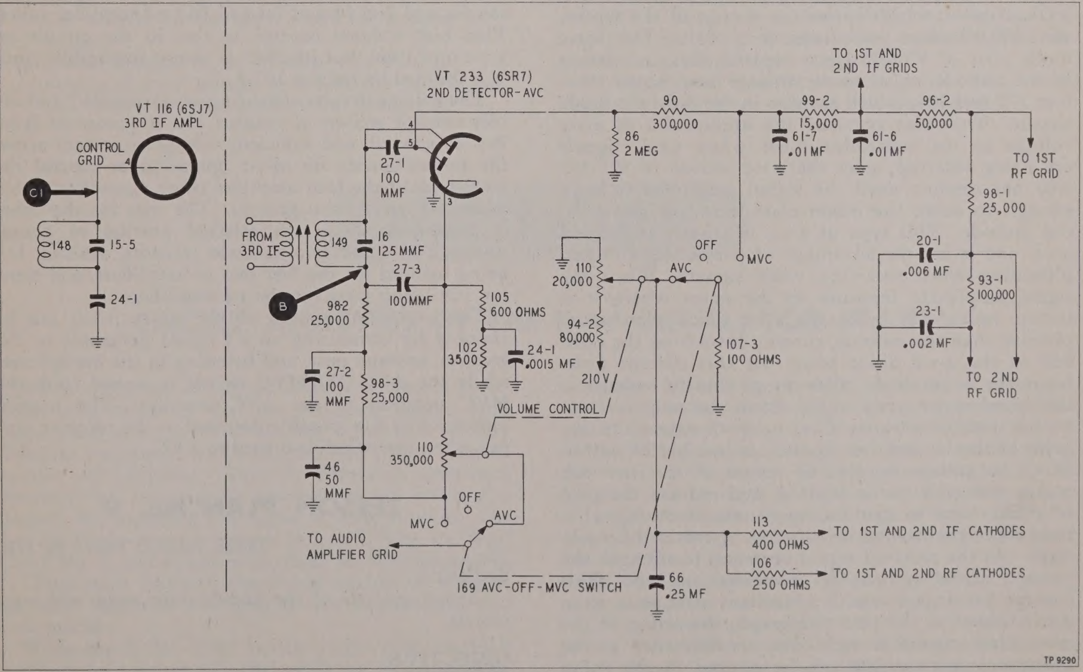

VT 116 (6SJ7)
3RD IF AMPL
CONTROL GRID
4
C1
148
15-5
24-1
VT 233 (6SR7)
2ND DETECTOR-AVC
4
5
3
27-1
100
MMF
FROM
3RD IF
149
16
125 MMF
27-3
100MMF
B
98-2
25,000
27-2
100
MMF
98-3
25,000
46
50
MMF
105
600 OHMS
102
3500
24-1
.0015 MF
110
350,000
OFF
AVC
MVC
TO AUDIO
AMPLIFIER GRID
169 AVC-OFF-MVC SWITCH
VOLUME CONTROL
110
20,000
94-2
80,000
210 V
90
300,000
86
2 MEG
OFF
AVC
MVC
107-3
100 OHMS
66
.25 MF
113
400 OHMS
TO 1ST AND 2ND IF CATHODES
106
250 OHMS
TO 1ST AND 2ND RF CATHODES
TO 1ST AND
2ND IF GRIDS
99-2
15,000
61-7
.01 MF
61-6
.01 MF
96-2
50,000
TO 1ST
RF GRID
98-1
25,000
20-1
.006 MF
93-1
100,000
23-1
.002 MF
TO 2ND
RF GRID
TP 9290

Figure 13. 2nd-Detector and A-V-C Circuits

The detector diode conducts only on the positive swings of the input signal. In order to filter out the r-f component of the input signal, a large filter network is employed in the detector circuit. The filter consists of capacitors 27-2, 27-3, and 46, and resistors 98-2 and 98-3, and its function is to pass the a-f component of the signal to the audio stage, and to provide an alternate path for r-f currents. Capacitor 27-2 and 46 by-pass the r-f to ground; capacitor 27-3 provides a short r-f path from the detector-diode plate return to the cathode.

Two test points are used for checking the operation of the 2nd-detector circuit; these test points are also utilized for checking certain other stages. For example, an abnormal indication at secondary test point C1, previously used in checking the 3rd i-f stage, will mean that the fault is located in either the 3rd i-f stage or the 2nd-detector stage; voltage or resistance measurements will reveal the component at fault. Key test point B, located in the 2nd-detector circuit at the junction of capacitors 16 and 27-3 and resistor 98-2, is primarily used to check the over-all operation of the audio stage, but it may also be used as a secondary test point in trouble-shooting; in that case an abnormal indication will mean that the fault lies in one of the detector filter components. Figure 11 shows the physical location of test point B.

AUTOMATIC VOLUME CONTROL

The a-v-c circuit functions when switch 169 (AVC-OFF-MVC) is in the AVC position (see figure 13). Capacitor 27-1 couples the a-v-c diode plate to the 2nd-detector-diode plate. As stated before, the audio output level is selected by the use of the INCREASE VOL. control, which varies the setting of the tap on the 350,000-ohm potentiometer (110). The a-v-c diode plate of VT-233 has a negative bias, in relation to the cathode, equal to the voltage drop across resistors 102 and 105, which are also in the 3rd i-f cathode circuit. This bias prevents the application of a-v-c voltage to the controlled tubes when weak signals are being received, since the a-v-c section of VT-233 will not conduct until the signal amplitude is large enough to make the diode plate more positive than the cathode. This type of a-v-c is known as delayed a.v.c. and it has the advantage of permitting full amplification when receiving weak signals. When the signal amplitude increases to the point where it is strong enough to make the a-v-c diode plate more positive than the cathode, current flows from the cathode to the a-v-c diode plate. As this current flows from the a-v-c diode plate to ground, a voltage is developed across resistor 86. From the negative side of this resistor an a-v-c filter network extends to the grids of the 1st and 2nd i-f and 1st and 2nd r-f amplifiers; the voltage applied by means of this network makes the grids more negative and reduces the gain of these stages so that the amplitude of the signal is reduced to the desired level before it enters the audio stage. As the received signal decreases in strength the voltage across resistor 86 decreases and the grids become less negative, with a resultant increase in gain. As indicated in the next paragraph, the action of the a-v-c filter circuit is such that no difference in the average signal strength can be noticed in the audio output; the reception of keyed signals (c.w.) will not be interfered with, since the filter circuit allows only slow variations in signal strength to affect the grids of the controlled tubes.

In order that the a-v-c circuit may accomplish its purpose, the a-v-c voltage must vary only in accordance with the slow variations of increasing and fading in the carrier signal. It is necessary, therefore, to filter out the i-f and a-f components. This is accomplished by the use of a number of filter networks, having the proper time constants, which are intended to smooth out voltage variations and provide an easy r-f path to ground. It may be noted that, since the a-v-c network connects five stages together, some undesirable interaction would take place if the i-f and a-f signals in the 2nd-detector a-v-c stage were not isolated from the reminder of the a-v-c network.

By referring to the simplified schematic, the following filter components can be located: in the a-v-c stage, resistors 90 and 99-2 and capacitor 61-7; in the 2nd i-f stage, capacitor 61-6. In the 2nd r-f stage, resistors 96-2 and 98-1 and capacitor 20-1 are in the circuit for all positions of band switch 162-1. In the switch positions for bands 3 and 4, resistor 93-1 and capacitor 23-1 are added to the circuit.

When the AVC-OFF-MVC control is switched to the OFF position, it opens the 28-volt d-c line from the aircraft power supply to the input of the dynamotor, thus making the set inoperative. When the switch is in the MVC position, the a-v-c circuit is grounded through the 100-ohm resistor 107-3, and the 350,000-ohm section of resistor 110 is no longer a potentiometer. Thus, the volume of the audio output is no longer controlled by setting the audio level of the output tube; instead, the 20,000-ohm potentiometer section of resistor 110 becomes the main volume control, and it functions by varying the cathode bias of the 1st and 2nd i-f and 1st and 2nd r-f amplifier tubes. This bias volume control is also in the circuit on a-v-c operation, but its effect is almost negligible, since it is shunted by resistor 107-3.

The voltage divider consisting of resistor 94-2 and the bias control section of resistor 110 is connected from B+ to ground, and sufficient voltage is present across the potentiometer on m-v-c operation to control the sensitivity of the four amplifier tubes. Capacitor 66 by-passes r-f currents to ground. The bias for the tubes is developed across the selected portion of potentiometer 110 and two cathode resistors, resistor 113 being utilized for the first two i-f amplifiers, and resistor 106 being used for the r-f amplifiers.

The over-all operation of the a-v-c circuit can be checked by connecting an r-f signal generator to the receiver antenna post, and listening in the headphones while the AVC-OFF-MVC switch is turned from the MVC position to the AVC position. The normal indication is a noticeable decrease in the receiver output when the switch is turned to AVC.

LESSON PLAN No. 9

TIME ALLOTTED: ¾ HR.

SUBJECT

Circuit analysis of the 2nd-detector stage and a-v-c circuit.

OBJECTIVE

To analyze the 2nd-detector and a-v-c circuits.

INTRODUCTION

The 2nd-detector and a-v-c circuits employ two diodes in the same tube. Although their functions are quite different, the two circuits are interdependent on a-v-c operation.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram) and briefly review the action of the 2nd-detector and a-v-c circuits.
2. Display Wall Chart No. 2 (schematic diagram) and point out the 2nd-detector and a-v-c circuits.
3. Discuss the type of tube used and point out what circuit each tube element is in.
4. Draw the schematic diagram of the 2nd-detector stage (figure 13) on the blackboard.
5. Explain the method of coupling between the 3rd i-f stage and the 2nd-detector stage, and discuss the advantages of high-level detection.
6. Explain the functioning of the 350,000-ohm section of resistor 110, and its use for setting the audio level.
7. Discuss the method used to filter out all but the audio signal in the detection process, and point out the components in the filter circuit.
8. Point out the test points in the circuit which are applicable to the 2nd-detector stage, and discuss their use.
9. Point out the physical location of the test points on the receiver.
10. Draw the simplified schematic of the a-v-c circuit (figure 13) on the blackboard.
11. Explain in detail the following items concerning the a-v-c circuit, and identify the components concerned:
    a. Use of bias on the a-v-c diode for delayed a-v-c action.
    b. Use of resistor 86 to develop a-v-c voltage.
    c. Action of a-v-c voltage to reduce the gain of certain tubes, and the result of this reduction.
    d. Reverse action when signal strength decreases.
12. Discuss the necessity for an a-v-c voltage which varies only with slow carrier-voltage variations.
13. Point out the filter network and identify the components in the network.
14. Mention the use of the OFF position of the AVC-OFF-MVC switch.
15. Discuss the method of volume control when the AVC-OFF-MVC switch is in the MVC position, and emphasize the use of the 20,000-ohm section of resistor 110.
16. Identify the components in the bias control circuit.
17. Discuss the method used to check the operation of the a-v-c circuit.

CONCLUSIONS

There are no specific test points provided solely for checking the operation of the 2nd-detector and a-v-c circuits. However, certain test points used for other stages will aid in isolating trouble if it is located in either circuit.

ORAL QUIZ

1. What type of tube is used in the 2nd-detector and a-v-c circuits?
2. Which resistor is used for volume control in a-v-c operation? In manual operation?
3. What is the function of capacitors 27-2, 27-3, and 46 in the 2nd-detector circuit?
4. If one of the above capacitors is shorted, what key test point will isolate the trouble?
5. Why is the a-v-c diode plate biased?
6. What is the function of capacitor 27-1?
7. Where is the a-v-c voltage developed?
8. What happens to the voltage at the 2nd r-f amplifier control grid when the received signal increases in amplitude in a-v-c operation?
9. Identify the cathode resistors which help to develop the voltage for manual volume control.

LECTURE No. 9

CIRCUIT ANALYSIS OF THE C-W OSCILLATOR STAGE

When reception of unmodulated c-w signals is desired, it is necessary that the incoming signal, after conversion, be mixed with another signal of a slightly different frequency, which is generated in the receiver by the c-w oscillator. Since the frequency difference between the two signals amounts to an audio frequency, the incoming c-w signal is made audible. The c-w oscillator stage is shown in block form on Wall Chart No. 1, and in schematic form on Wall Chart No. 2. This stage employs the triode section of VT-233, the tube which is also used in the 2nd-detector and a-v-c circuits.

When the C. W. OSC. switch (168) is in the OFF position (see figure 14) the oscillator is inoperative, because the triode plate of VT-233 is disconnected from the 130-volt bus (which, in turn, is connected to the 210-volt line through dropping resistor 97-2 and the connector plug). When switch 168 is turned to the ON position, voltage is applied to the plate, and oscillations begin. The plate is connected to the 130-volt bus through plate load resistor 97-1, across which the oscillator output voltage is developed; this resistor also drops the d-c voltage to the proper level for the plate.

The c-w oscillator is a Hartley type, with a tuned grid and plate feedback. Since the incoming c-w signal is converted to the i-f (915 kc.) by the action of the 1st-detector, heterodyne-oscillator tube, just as voice signals are, the c-w oscillator must operate in the 915 kc. region. Oscillations take place in the tuned

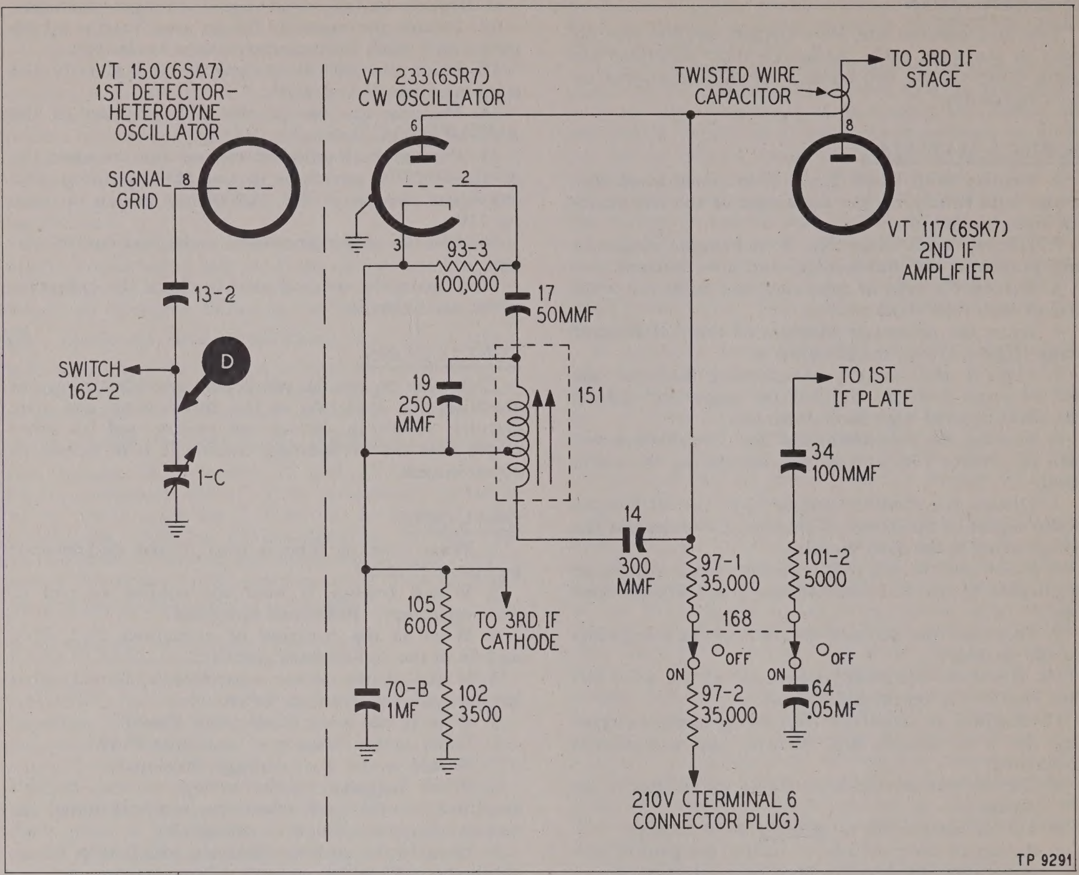
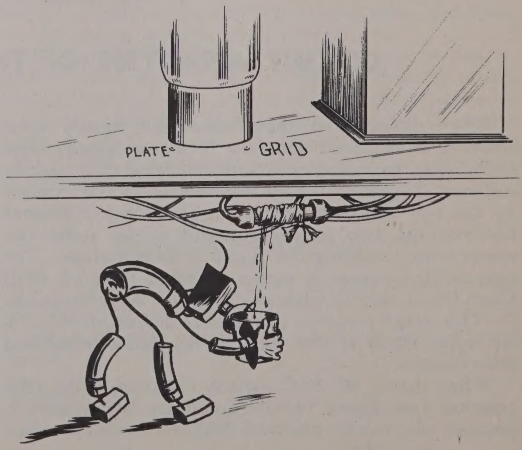

VT 150 (6SA7)
1ST DETECTOR-HETERODYNE OSCILLATOR
SIGNAL GRID
8
13-2
SWITCH 162-2
D
1-C
VT 233 (6SR7)
CW OSCILLATOR
6
2
3
93-3
100,000
17
50MMF
19
250 MMF
151
14
300 MMF
105
600
TO 3RD IF CATHODE
70-B
1MF
102
3500
TWISTED WIRE CAPACITOR
TO 3RD IF STAGE
8
VT 117 (6SK7)
2ND IF AMPLIFIER
TO 1ST IF PLATE
34
100MMF
97-1
35,000
101-2
5000
168
OFF
ON
OFF
ON
97-2
35,000
64
.05MF
210V (TERMINAL 6 CONNECTOR PLUG)
TP 9291

Figure 14. C-W Oscillator Circuit

circuit composed of capacitor 19 and the grid section of coil 151, which is an autotransformer. Voltage in the proper phase to maintain the oscillations is fed from the plate circuit to the grid circuit by means of the primary winding of autotransformer 151. Due to the low d-c plate voltage, the oscillator operates at a very low level, producing a signal of small amplitude; this minimizes harmonic generation and limits stray pickup, by other circuits, of the oscillator output. The components of the oscillator tank circuit are designed to compensate for the effects of rapid temperature changes.

In order that the operator may vary the pitch of the audio signal in the headphones, the BEAT FREQ. control on the front panel operates a movable iron core in the autotransformer. By varying the position of the core, the inductance in the tuned circuit, and the frequency of oscillation, are changed, resulting in a different audio tone. The core is so mounted that one turn of the BEAT FREQ. control will vary the frequency of oscillation approximately 4000 cycles each side of the zero-beat position.

Grid bias for the oscillator is developed across grid-leak resistor 93-3; capacitor 17 blocks the grid current and forces it to flow through the grid-leak resistor.



Capacitor 14 couples the oscillator plate and grid circuits and blocks the d-c plate voltage. Capacitor 70-B acts as the cathode by-pass capacitor. The d-c path from cathode to ground is provided by connecting the cathode of VT-233 to the cathode of the 3rd i-f tube, which is grounded through resistors 102 and 105 in series.

The output of the c-w oscillator is fed to the plate circuit of the 2nd i-f tube by means of the capacitance of a twisted wire, and is mixed with the incoming c-w signals in the 3rd i-f amplifier tube. The 3rd i-f tube provides sufficient amplification of the c-w oscillator output, despite the very low level of operation of the oscillator stage. The output of the 3rd i-f amplifier tube contains the intermediate and c-w oscillator frequencies; these signals are detected and the output of the 2nd-detector stage is an audio signal with a frequency equal to the difference between the i-f and the c-w oscillator frequency.

When the C.W.OSC. switch is turned to ON, capacitor 64 and resistor 101-2, in series, are connected to the plate of the 1st i-f tube through coupling capacitor 34; as previously mentioned, this circuit provides a path to ground for i-f signals and, thus, has the effect of reducing the gain of the 1st i-f stage. This prevents overloading of the 3rd i-f tube on c-w reception, which might otherwise occur, since the c-w oscillator output is fed to this tube. Capacitor 64, when switched into the circuit, also has the effect of increasing the a-v-c time constant.

The over-all operation of the c-w oscillator stage may be checked by the use of key test point Ⓓ, which is located at the ungrounded side of the 1st-detector section of the ganged tuning capacitor (the same location as test points Ⓒ and Ⓔ). After the i-f and audio circuits have been cleared of trouble by the use of a trouble-shooting procedure, the operation of the c-w oscillator is checked by connecting a signal generator between test point Ⓓ and ground, setting the generator for an unmodulated 915-kc. signal, and listening in the headphones. The normal indication is a whistle in the headphones.

LESSON PLAN No. 9

TIME ALLOTTED: ½ HR.

SUBJECT

Circuit analysis of the c-w oscillator stage.

OBJECTIVE

To analyze the c-w oscillator circuit.

INTRODUCTION

The c-w oscillator is the source of the oscillations which are mixed with the incoming c-w signals to produce an audible signal in the headphones.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram) and briefly review the action of the oscillator.

2. Display Wall Chart No. 2 (schematic diagram) and point out the c-w oscillator circuit.

3. State the type of tube used.

4. Draw the schematic diagram of the c-w oscillator circuit (figure 14) on the blackboard.

5. Explain the use of switch 168, emphasizing its control of the plate voltage of the c-w oscillator.

6. Point out the plate-voltage dropping resistor and the plate load resistor.

7. Discuss the type of oscillator and its frequency.

8. Identify the tuned-grid-circuit components and explain the feedback method.

9. Discuss the advantages of low-level operation of the oscillator.

10. Explain how the tone of the output signal may be varied by the use of the BEAT FREQ. control.

11. Explain the grid-leak circuit, and the use of capacitors 14 and 70-B.

12. Point out the d-c path from the cathode of VT-233 to ground.

13. Discuss the coupling of the c-w oscillator output to the plate circuit of the 2nd i-f tube.

14. Discuss the characteristics of the output of the 3rd i-f amplifier tube and the 2nd-detector stage on c-w reception.

15. Discuss the functions of capacitor 64 and resistor 101-2 when the C.W. OSC. switch is in the ON position.

16. Point out the key test point in the circuit and explain its use.

17. Point out the physical location of the test point on the receiver.

CONCLUSIONS

Proper operation of the c-w oscillator is essential to c-w reception. An inoperative condition of this stage can be detected by the use of one key test point.

ORAL QUIZ

1. Why is a c-w oscillator necessary in order to hear c-w signals?

2. What is the approximate operating frequency of the c-w oscillator? Why is this frequency used?

3. When the BEAT FREQ. control on the front panel is manipulated, what physical action occurs? What electrical changes occur in the oscillator circuit?

4. Why is voltage fed from the plate circuit to the grid circuit? What component is used to get the proper feedback?

5. Why is the oscillator output coupled to the 2nd i-f amplifier plate?

6. What type of bias is used for the oscillator tube? Identify the components concerned with the biasing method.

7. Why is resistor 101-2 shunted across the plate circuit of the 1st i-f amplifier tube for c-w reception?

8. Give the location of the key test point which checks the operation of the c-w oscillator stage.

EXPERIMENT No. 6

TIME ALLOTTED: 1½ HR.

SUBJECT

2nd detector, a.v.c. and c-w oscillator.

OBJECTIVE

To become familiar with the methods used to trouble-shoot the 2nd-detector, a-v-c, and c-w oscillator circuits.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J (in good operating condition).
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-f signal generator (200 kc. to 18 mc.).
1 A-f signal generator.
1 D-c voltmeter with 100-volt and 500-volt ranges (20,000-ohms-per-volt meter preferred).
1 Ohmmeter.
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Remove the small plate on the front panel. Connect the power source to the receiver. Plug the headphones into the TEL. JACK.

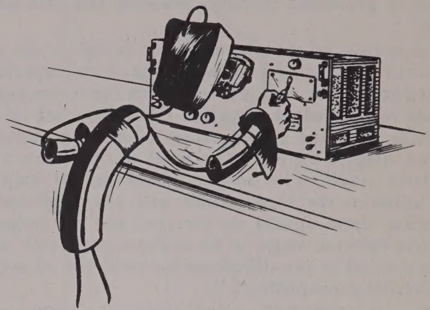
PROCEDURE

1. The over-all operation of the 2nd-detector circuit can be checked by introducing a modulated 915-kc. signal at key test point C1 and listening to the receiver output; the normal indication is a clear tone in the headphones. This test point has already been used to check the operation of the 3rd i-f stage, in the previous experiment; it is located at the grid of the 3rd i-f amplifier tube. In trouble-shooting this circuit later in the experiment, use the same procedure which was utilized for test point C1 in the experiment on the 3rd i-f stage.

2. If this receiver had a defect in the 2nd-detector circuit and an abnormal indication were obtained at test point C1, the components in the 2nd-detector filter circuit could be checked by introducing an a-f signal at key test point B. Locate key test point B at the secondary coil of the 3rd i-f transformer on the underside of the chassis (the lug nearest the front of the receiver). The primary purpose of test point B is to check the over-all operation of the audio-amplifier circuit, but it can also be used as a secondary test point to check the 2nd-detector filter circuit.

3. Connect the a-f signal generator output to test point B and set it for a strong output. Connect the signal-generator ground lead to the receiver ground post. Turn on the generator and set the receiver controls as follows:

a. DIAL LIGHTS control fully clockwise.



b. INCREASE VOL. control fully clockwise.
c. C. W. OSC. switch to OFF.
d. CRYSTAL switch to OUT.
e. AVC-OFF-MVC switch to AVC.

Allow the receiver and signal generator to warm up for several minutes. A loud, clear tone, heard in the headphones, is the normal indication. If this were a defective set and an abnormal indication were obtained when using this test point, the trouble would lie in the following components: resistor 98-2, 98-3, or 110; capacitor 25, 27-2, or 46. Disconnect the a-f signal generator.

4. The over-all operation of the a-v-c circuit can be checked by introducing a modulated r-f signal at the antenna post of the receiver, and listening to the receiver output. Connect the signal-generator output to the antenna post of the receiver, and the signal-generator ground lead to the ground post of the receiver, using a short heavy lead. With the INCREASE VOL. control on the receiver fully clockwise and the AVC-OFF-MVC switch in the MVC position, turn on the signal generator and tune it and the receiver to 3.0 mc. Adjust the signal generator so that a loud, clear tone is heard in the headphones. Turn the AVC-OFF-MVC switch to AVC. A clear tone will still be heard in the headphones, but the volume of the signal will decrease noticeably; this is the normal indication. If this receiver were defective and an abnormal indication were obtained when performing this check, the trouble would be in the a-v-c section of VT-233, resistor 86, or the various resistors and capacitors in the a-v-c filter circuit.

5. To check the operation of the c-w oscillator circuit, locate key test point D at the 1st-detector section of the ganged tuning capacitor (the third section from the right). This location is the same as that used for key test points C and E, which were used previously to check other circuits. Set the r-f signal generator for an unmodulated output of 915 kc., and connect the output to test point D. Adjust the generator for a weak signal and turn it on; set the receiver controls as follows:

a. DIAL LIGHTS control fully clockwise.
b. INCREASE VOL. control fully clockwise.
c. C.W. OSC. switch to ON.

d. CRYSTAL switch to OUT.

e. AVC-OFF-MVC switch to MVC.

f. BAND SWITCH to 200—500 kc.

Vary the BEAT FREQ. control. A whistle of varying pitch will be heard in the headphones; this is the normal indication. If this were a defective receiver and the use of this test point produced an abnormal indication, the trouble would lie in the c-w oscillator section of VT-233 or in its associated components, including capacitors 14 and 17, and autotransformer 151.

6. Set the receiver controls as follows:

a. BAND SWITCH and TUNING set for 200 kc.

b. CRYSTAL SWITCH to OUT.

c. C.W. OSC. switch to OFF.

d. INCREASE VOL. control fully clockwise.

e. DIAL LIGHTS control fully clockwise.

f. AVC-OFF-MVC switch to MVC.

g. Headphones and signal generator disconnected.

Using the d-c voltmeter, take voltage readings between all of the socket terminals of VT-233 and ground. Draw up a chart showing the voltage between each terminal and ground, and indicate the tube element which is being checked at each terminal.

7. Disconnect the power plug. Leave the receiver controls in the same position. Using the ohmmeter, take resistance readings between all of the socket terminals of VT-233 and ground. Draw up a chart showing the resistance between each terminal and ground, and indicate the tube element which is being checked at each terminal. Readings at terminal 5 should be made for both the MVC and AVC positions of the AVC-OFF-MVC switch. All other readings should be made for the MVC position only.

8. Request the instructor to place a defect in one of the circuits associated with VT-233. By making use of test points, isolate the individual circuit containing the fault. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

9. Request the instructor to place another defect in the circuits associated with VT-233. By making use of test points, isolate the individual circuit containing the fault. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

10. Restore the receiver to its original condition.

CONCLUSIONS

1. If the resistance reading between socket terminal 3 of VT-233 and ground is 600 ohms, what component is probably defective?

2. What is the d-c voltage on the triode plate of VT-233 when switch 168 is in the OFF position? In the ON position?

3. What component is probably at fault if the pitch of the output signal, during c-w reception, cannot be changed when the BEAT FREQ. control is varied?

4. Name several components in which the fault might be located if the d.c. voltage between socket terminal 6 of VT-233 and ground is approximately 130 volts, with switch 168 in the ON position?

5. Why is an a-f generator used at key test point Ⓑ? What components in the 2nd-detector circuit can be checked with this test point?

6. Why is an unmodulated signal from the signal generator used to check the operation of the c-w oscillator? Could an effective test be made if the signal were modulated?

LECTURE No. 10

CIRCUIT ANALYSIS OF THE AUDIO-AMPLIFIER STAGE

The audio stage amplifies the audio signal which is passed to it from the 2nd detector. A reasonable amount of signal fidelity is expected of this stage, but this feature is not emphasized, since high fidelity is not necessary. The audio stage is shown in block form on Wall Chart No. 1, and in schematic form on Wall Chart No. 2. The stage uses a VT-152 (6K6GT) pentode power-amplifier tube, which operates as a Class A amplifier.

The use of only one stage of audio amplification results in two important advantages: the possibility of microphonics resulting from high audio amplification is eliminated and dynamotor ripple filtering is simplified. This stage is designed to deliver a large amount of power to the output transformer (155-A), since the receiver is intended to have sufficient output for the aircraft interphone system, as well as for two headphones at the receiver itself.

The output of the 2nd detector is coupled to the grid of the audio-amplifier tube by means of capacitor 25 and resistor 96-1 (see figure 15). The audio-amplifier tube operates at a fixed negative bias suitable for Class A operation in order to provide a relatively undistorted amplified output. The bias consists of the voltage drop across resistors 108-1 and 108-2 (in parallel), which are connected to the negative power supply line. Coil 155-B, which is part of the audio assembly containing audio transformer 155-A, is in the biasing circuit, and functions as a power-supply filter. In order to prevent a-f currents from feeding back to the power supply through the fixed bias connection, a filter network, consisting of resistor 91 and capacitor 63-2, is utilized. Resistor 87-5 is the grid resistor, across which the a-f signal is developed. Resistor 96-1 is a grid current-limiting resistor, which prevents overloading of the tube, with the resulting distortion, when strong signals are received.

The cathode and suppressor grid of VT-152 are tied together and are at ground potential. Since the primary purpose of this tube is power amplification, the shielding effect of the screen grid is not as important as its function of accelerating the electrons so that large values of plate current can be drawn. The screen grid is connected directly to the high-voltage line, the plate is connected through the primary winding of transformer 155-A and has a slightly lower d-c volt-

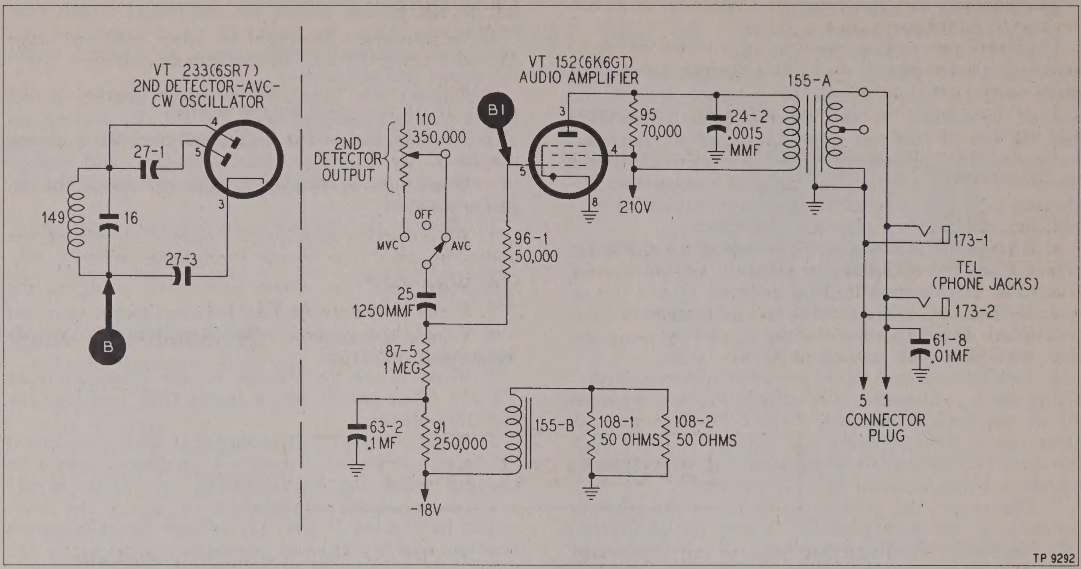

VT 233(6SR7)
2ND DETECTOR-AVC-
CW OSCILLATOR
4
27-1
5
3
149
16
27-3
B
2ND
DETECTOR
OUTPUT
110
350,000
OFF
MVC
AVC
25
1250MMF
87-5
1 MEG
63-2
.1 MF
91
250,000
-18V
B1
VT 152(6K6GT)
AUDIO AMPLIFIER
3
4
5
8
95
70,000
210V
24-2
.0015
MMF
96-1
50,000
155-A
155-B
108-1
50 OHMS
108-2
50 OHMS
173-1
TEL
(PHONE JACKS)
173-2
61-8
.01MF
5 1
CONNECTOR
PLUG
TP 9292

Figure 15. Audio-Amplifier Circuit

age. Capacitor 24-2 is the plate by-pass capacitor for any r-f that is in the circuit. The primary winding of audio transformer 155-A is shunted by resistor 95, which flattens out the response characteristics of the transformer over the audio range. The transformer terminal connections are indicated on the top of the transformer shield. The schematic diagram shows the transformer secondary connected for high-impedance output. If low-impedance output is desired, the center tap is used.

Phone jacks 173-1 and 173-2 are connected across the secondary of transformer 155-B; one side of the secondary is grounded. These phone jacks, which are physically located on the front panel of the receiver, permit headphone reception of the audio output. Capacitor 61-8 is the audio-output filter.

The key test point for the audio stage is located at the secondary winding of the 3rd i-f transformer (149), and is designated (B). (See figure 11 for physical location). The over-all operation of the audio-amplifier stage can be checked by connecting an a-f signal generator between test point (B) and ground, and listening for a clear tone in the headphones. As mentioned previously, this test point also checks the components of the 2nd-detector filter network. Secondary test point (B1) may be used as an aid in further isolating trouble. It is located at the grid of the audio amplifier tube. (See figure 8 for physical location.)

LESSON PLAN No. 10

TIME ALLOTTED: ½ HR.

SUBJECT

Circuit analysis of the audio-amplifier stage.

OBJECTIVE

To analyze the audio-amplifier circuit.

INTRODUCTION

Due to the design of the receiver, which incorporates three i-f amplifier stages and a high-level detector, only one stage is necessary to produce the desired amount of audio-signal amplification.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block diagram) and briefly review the action of the audio stage.
2. Display Wall Chart No. 2 (schematic diagram) and point out the audio circuit.
3. State the type of tube and class of amplification which are used.
4. Discuss the advantage secured through the use of only one stage of audio amplification.
5. Explain why power amplification is desirable.
6. Draw the schematic diagram (figure 15) on the blackboard.
7. Point out the capacitor (25) which couples the 2nd detector to the audio stage.
8. Discuss the biasing method and point out the components which develop the bias voltage; indicate the filter network in the grid circuit and discuss the functions of resistors 87-5 and 96-1.
9. Point out the cathode and suppressor-grid connections to ground.
10. Mention the electron-accelerating function of the screen grid.
11. Discuss the plate and screen-grid connections to the high-voltage bus.

12. Mention the functions of capacitor 24-2 and resistor 95 in the plate circuit.

13. Point out the connection of the phone jacks across the secondary of audio transformer 155-A, and mention the use of capacitor 61-8.

14. Point out the key and secondary test points and explain their use.

15. Point out the physical location of the test points on the receiver.

CONCLUSIONS

One stage of amplification is provided for the audio signal from the 2nd-detector circuit. An inoperative condition of this stage can be detected by the use of one key test point; the trouble can be further isolated by the use of a secondary test point, and by using the key test point again as a secondary test point.

ORAL QUIZ

1. Name some advantages of using only one stage of audio amplification. Name a disadvantage.

2. What provision is made in the design of the audio circuit for linear amplification?

3. Why is the audio stage designed as a power amplifier?

4. What type of biasing is used for the audio-amplifier tube?

5. What device couples the output circuit of the audio-amplifier tube to the headphone jacks?

6. Why does the screen grid have a higher d-c voltage than the plate of VT-152?

7. Where is test point B1 located in the circuit? What does it check?

EXPERIMENT No. 7

TIME ALLOTTED: 1½ HR.

SUBJECT

Audio amplifier stage.

OBJECTIVE

To become familiar with the methods used to trouble-shoot the audio-amplifier stage.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J.
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 A-f signal generator.
1 D-c voltmeter with 100 and 500-volt ranges (20,000-ohms-per-volt meter preferred).
1 Ohmmeter.
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Remove the small plate on the front panel. Connect the power source to the receiver. Plug the headphones into the TEL. JACK. Connect the a-f signal-generator ground lead to the ground post of the receiver.

PROCEDURE

1. The over-all operation of the audio stage can be checked by introducing an a-f signal at key test point B, in the 2nd-detector circuit, and listening to the receiver output. Test point B was used in the previous experiment; locate it at the secondary winding of the 3rd i-f transformer on the underside of the chassis (the lug nearest the front of the receiver). Connect the a-f signal-generator output to the test point, adjust it for a strong output, and turn it on. Set the receiver controls as follows:

a. DIAL LIGHTS control fully clockwise.
b. INCREASE VOL. control fully clockwise.
c. C.W. OSC. switch to OFF.
d. CRYSTAL switch to OUT.
e. AVC-OFF-MVC switch to AVC.

Allow the receiver and signal generator to warm up for several minutes. A loud, clear tone, heard in the headphones, is the normal indication. If this were a defective receiver, an abnormal indication when using this test point would mean that the trouble is in the audio stage, and secondary test point B1 would be used next to isolate the trouble.

2. Locate test point B1 at the control grid of the audio-amplifier tube (socket terminal 5). This test point is reached through the small opening in the front panel; the tube socket terminals are located just above the heterodyne-oscillator section of the ganged tuning capacitor (first section on the left). Terminal 5 is the terminal farthest to the left when the receiver is viewed from the front. Connect the a-f signal-generator output to this test point; leave all receiver and signal-generator controls in the positions they are already in. A loud, clear tone, heard in the headset, is the normal indication. If this were a defective receiver and there were an abnormal indication when using this test point, the trouble would be in the audio-amplifier tube (VT-152) or its associated components, including transformer 155-A and capacitor 24-2.

3. As mentioned in the previous experiment, key test point B can be used as a secondary test point. Thus, if there is an abnormal indication when test point B is used as a key test point and the indication is normal when test point B1 is used, test point B can be used again as a secondary test point; in this case, the procedure given in paragraph 1 should be repeated, and an abnormal indication means that the trouble lies in the 2nd-detector filter-circuit components, which include resistors 98-2, 98-3, and 110, and capacitors 25, 27-2, and 46.

4. Set the receiver controls as follows:
a. BAND SWITCH and TUNING set for 200 kc.
b. CRYSTAL switch to OUT.
c. C.W. OSC. switch to OFF.
d. INCREASE VOL. control fully clockwise.
e. DIAL LIGHTS control fully clockwise.
f. Headphones and signal generator disconnected. Using the d-c voltmeter, take voltage readings between all of the socket terminals of the audio-amplifier tube and ground. CAUTION! HIGH VOLTAGE! Draw up a chart showing the voltage between each terminal and ground, and indicate the tube element which is being checked at each terminal. Read the screen-grid and plate voltages on the 500-volt scale.

5. Disconnect the power plug. Leave the receiver controls in the same position. Using the ohmmeter, take resistance readings between all of the socket terminals and ground. Draw up a chart showing the resistance between each terminal and ground, and indicate the tube element which is being checked at each terminal.

6. Request the instructor to place a defect in the audio stage. By making use of test points, isolate the individual circuit at fault. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

7. Request the instructor to place another defect in the audio stage. By making use of test points, isolate the individual circuit at fault. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

8. Restore the receiver to its original condition.

CONCLUSIONS

1. How would the operation of VT-152 be affected if resistor 108-2 were shorted out of the circuit?

2. What component is probably at fault if the voltage between socket terminal 3 of VT-152 and ground is zero?

3. What terminals in the connector plug carry the audio output?

4. Name some of the components which might be at fault if the resistance reading between socket terminal 5 and ground is 400,000 ohms?

5. What would be the voltage reading between socket terminal 5 and ground if coil 155-B were open?

LECTURE No. 11

CIRCUIT ANALYSIS OF THE POWER SUPPLY

The aircraft power supply furnishes 28 volts d.c. for the receiver dynamotor, which in turn supplies all of the d-c high voltages required for the operation of the receiver (a maximum of 210 volts positive is required), and which also supplies 18 volts negative for the bias requirements of certain tubes. The 28-volts d-c input is also utilized for the dial lights and tube heaters. The power-supply circuit is shown in block form on Wall Chart No. 1 and in schematic form on Wall Chart No. 2 and in figure 16.

A 5-ampere, 25-volt fuse (186) is in the plus-28-volt line (see figure 16, power-supply schematic diagram) to switch 169 (AVC-OFF-MVC), which turns the set on and off. This fuse protects the receiver in case of large current surges from the aircraft power supply. Two dial lights (185) are connected from the positive low-voltage line to ground, through rheostat 111 (which is actuated by the DIAL LIGHTS control) and resistor 81. 6.3 volts is supplied to the heaters of all tubes from the low-voltage input. Resistors 84 and 85 are associated with the heater circuit and aid in securing the proper voltage across the heaters. Resistor 82 shunts three heaters in order to secure the proper amount of current flow, since the VT-152 heater draws .4 ampere and the shunted heaters draw .3 ampere. Capacitor 61-9 serves as the low-voltage-line by-pass capacitor.

In the dynamotor unit itself are a number of components that form the power-supply filters, which are intended to keep the d.c. as steady as possible by filtering out dynamotor ripple and any other form of a.c. Capacitor 417-B and filter choke 421 are used to filter the 28 volts input. Coil 420-2 is in the positive high-voltage bus, and coil 420-1 is in the negative high-voltage line. Capacitors 417-A, 418, and 419 form a series-parallel arrangement which is connected between the positive and negative high-voltage output. Two other components are used for dynamotor-output filtering, but they are not contained in the dynamotor assembly. Capacitor 70-A is connected to the positive high-voltage bus, and is contained in a shielded unit with capacitor 70-B, which is in the cathode circuit of the 2nd-dector stage. Choke 155-B is in the negative voltage-output line from the dynamotor; as mentioned before, it is contained in an assembly with the audio transformer (155-A).

Major test point ① checks the over-all operation of the dynamotor; this test point has already been used in Experiment No. 2. Test points A and A1 may be used as an aid in further isolating trouble in the power-supply circuits. These test points are all located at the dynamotor terminal strip (422), which is made available at a cutout in the left end-plate (see figure 17).

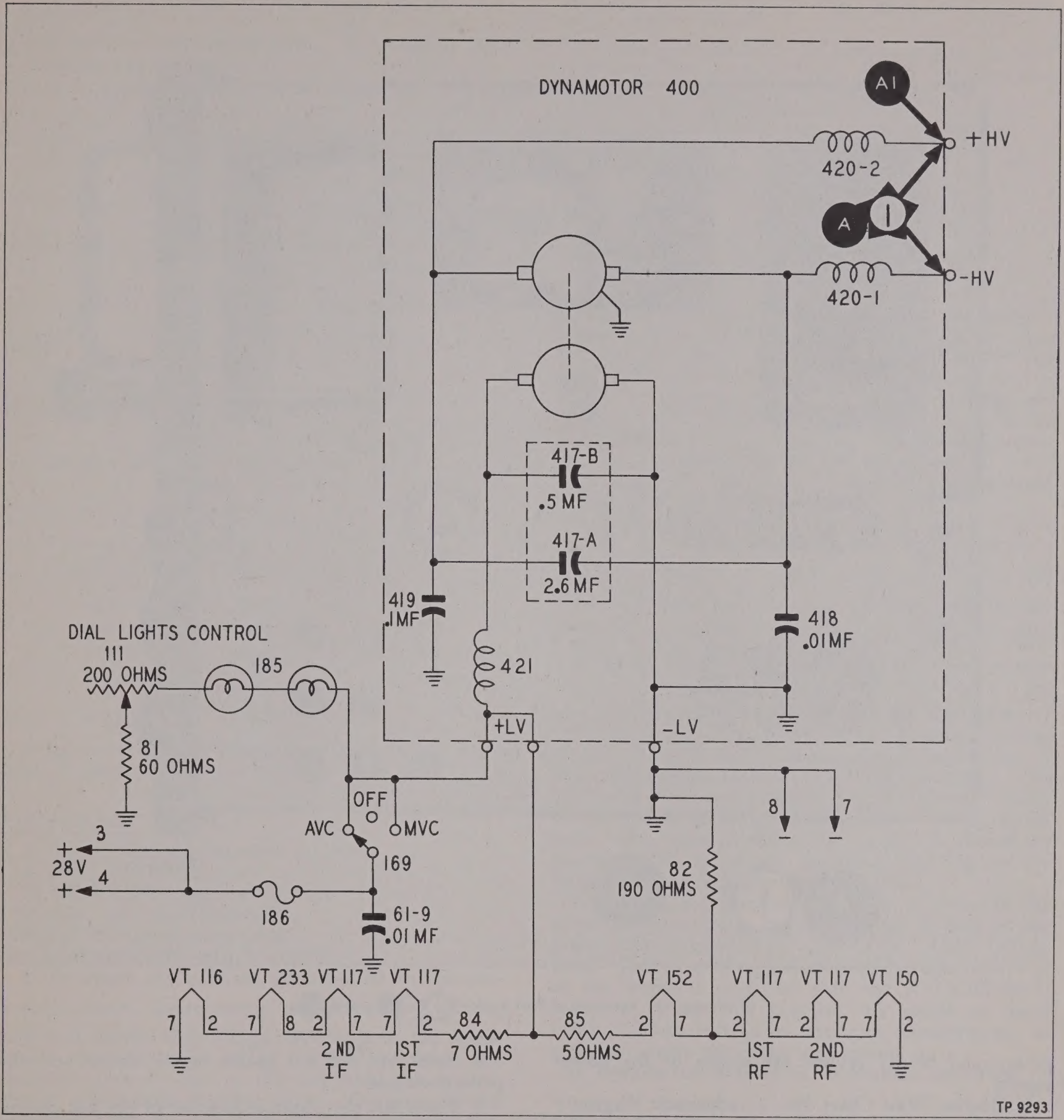

DYNAMOTOR 400
A1
A
1
+HV
-HV
420-2
420-1
417-B
.5 MF
417-A
2.6 MF
419
.1MF
418
.01MF
421
+LV
-LV
DIAL LIGHTS CONTROL
111
200 OHMS
185
81
60 OHMS
OFF
AVC
MVC
169
3
+
28V
4
+
186
61-9
.01 MF
8
7
82
190 OHMS
VT 116
VT 233
VT 117
VT 117
VT 152
VT 117
VT 117
VT 150
84
7 OHMS
85
5 OHMS
2ND IF
1ST IF
1ST RF
2ND RF
TP 9293

Figure 16. Power-Supply Circuit

LESSON PLAN No. 11

TIME ALLOTTED: ½ HR.

SUBJECT

Circuit analysis of the power supply.

OBJECTIVE

To analyze the power-supply circuit.

INTRODUCTION

The power for the receiver is derived from the dynamotor and, for certain circuits, directly from the 28-volt aircraft power supply. The dynamotor contains an extensive filter circuit to assure that any a-c ripple will be eliminated.

SUBJECT MATERIAL

1. Display Wall Chart No. 1 (functional block dia-

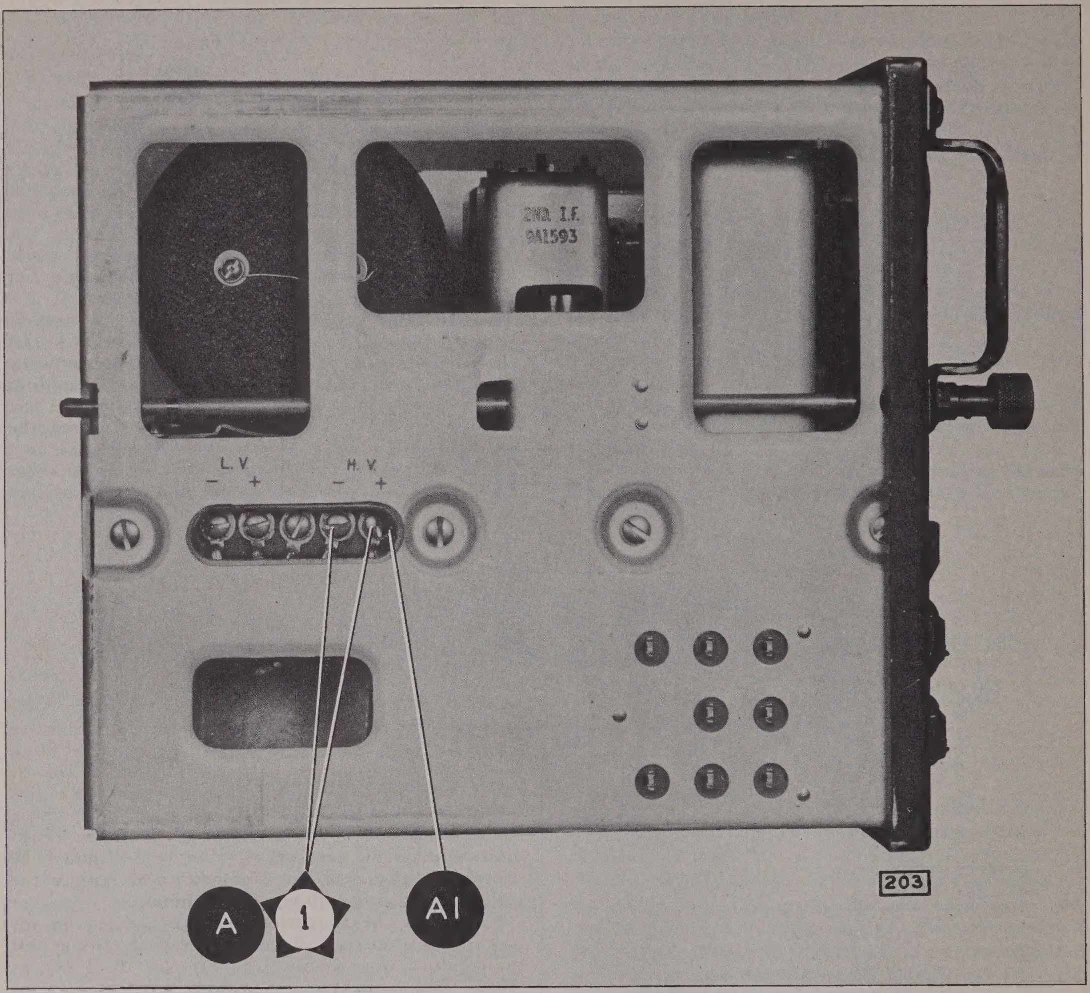


Figure 17. Location of Test Points 1, A, and AI

gram) and briefly review the action of the power supply.

2. Display Wall Chart No. 2 (schematic diagram) and point out the power-supply circuit. Draw the circuit on the blackboard.

3. Point out the plus and minus 28-volt input connections and discuss the functions of fuse 186 and switch 169.

4. Point out the dial-light circuit and identify the components.

5. Explain the tube-heater circuit and point out resistors 82, 84, and 85.

6. Identify the components in the power-supply filter circuit; indicate whether they are associated with the dynamotor input or output.

7. Point out the filter components which are not contained in the dynamotor unit (capacitor 70-A and choke 155-B).

8. Point out the test points in the circuit and explain their use.

9. Point out the physical location of the test points on the receiver.

CONCLUSIONS

An inoperative condition of the power-supply circuit can be detected by the use of major test point 1, and trouble can be isolated by the use of key test point A and secondary test point AI.

ORAL QUIZ

1. What is the maximum positive high voltage required for the operation of this receiver?

2. What is the rating of fuse 186?

3. How much voltage is required by the dial-light circuit?

4. How many heaters are there? What voltage does each heater require?

5. If a d-c voltmeter were placed across the plus and minus high-voltage terminals, what reading would you normally expect?

6. Which terminals in the connector plug are used to connect the aircraft power supply to the dynamotor?

EXPERIMENT No. 8

TIME ALLOTTED: 1 HR.

SUBJECT

Power-supply circuit.

OBJECTIVE

To become familiar with the methods used to trouble-shoot the power-supply circuit.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J.
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 D-c voltmeter with 300-volt range (20,000-ohms-per-volt meter preferred).
1 Ohmmeter.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Connect the power source to the receiver.

PROCEDURE

1. Set the receiver controls as follows:
a. DIAL LIGHTS control fully clockwise.
b. INCREASE VOL. control fully clockwise.
c. C.W. OSC. switch to OFF.
d. CRYSTAL switch to OUT.
e. AVC-OFF-MVC switch to OFF.

2. To check the over-all operation of the power-supply circuit, locate major test point 1 at the plus and minus high-voltage terminals of the dynamotor terminal strip (422). These terminals are available at a cut-out in the left end-plate on the chassis, just below the dynamotor. Connect the d-c voltmeter (300-volt range) between the two terminals. Turn the AVC-OFF-MVC switch to AVC, and allow the receiver to warm up. A voltmeter reading of 200 to 250 volts is the normal indication. If this receiver had a defect in the power-supply circuit, the reading would be abnormal, and key test point A and secondary test point A1 would be used to isolate the trouble.

3. Key test point A is also located across the plus and minus high-voltage terminals. Turn the AVC-OFF-MVC switch to OFF. Remove the lead which is connected to the minus high-voltage terminal by means of a spade terminal; removing this lead has the effect of isolating the dynamotor from the receiver circuits. With the d-c voltmeter connected between the plus and minus high-voltage terminals, turn the AVC-OFF-MVC switch to AVC. A voltmeter reading of 200 to 250 volts is the normal indication. If the receiver had a defect in the power supply and the use of this test point produced an abnormal indication, the trouble would lie in fuse 186, the 28-volt d-c power source, switch 169, the dynamotor, or associated components.

4. If this receiver had a defect in the power-supply circuit, resulting in an abnormal indication when major test point 1 is used, and the use of key test point A produced a normal indication, the trouble could be isolated by using secondary test point A1. Test point A1 is located at the plus high-voltage terminal. Turn the AVC-OFF-MVC switch to OFF and disconnect the voltmeter. Connect the ohmmeter from the test point to ground. An ohmmeter reading of 80,000 ohms ± 10% is the normal indication. If this were a defective receiver and the resistance at this test point were low, the next step would be to check for shorted tubes or by-pass capacitors. If the resistance were high, resistors 94-2 and 110 should be checked. Disconnect the ohmmeter and replace the lead to the minus high-voltage terminal.

5. Request the instructor to place a defect in the power-supply circuit. By making use of tests at test points, isolate the trouble. CAUTION! HIGH VOLTAGE! Before making connections or disconnections at the terminal strip, be sure the AVC-OFF-MVC switch is in the OFF position. By means of visual inspection and voltage or resistance measurements, as required, locate the defect and correct it.

6. Restore the receiver to its original condition.

CONCLUSIONS

1. What would be the voltage reading at test point A if fuse 186 is out of the fuse holder?

2. If the resistance reading between test point A1 and ground is 125,000 ohms, name several components which might be at fault.

3. Where can the 28-volt power source be easily checked in the receiver?

4. What components in the receiver would be affected, and in what way would they be affected, if resistor 84 became open?

5. What would be the effect on the operation of the receiver if coil 420-2 were shorted out of the circuit?

LECTURE No. 12

ALIGNMENT AND ADJUSTMENT

Radio Receiver BC-348-J, like other superheterodyne receivers, requires occasional alignment and adjustment for proper operation. The receiver tuning will drift due to aging of the receiver, replacement of parts, long usage, etc. Sometimes the need for alignment or adjustment will be obvious; at other times the need is revealed only by testing.

The following types of alignment and adjustment procedures may be found to be necessary in this receiver:

1. Alignment of the i-f transformers.
2. Calibration of the tuning dial with the ganged tuning capacitors.
3. Alignment of the r-f, 1st-detector and heterodyne-oscillator stages.
4. Neutralization of the crystal-filter circuit.
5. Alignment of the c-w oscillator.

ALIGNMENT OF I-F TRANSFORMERS

The i-f transformers are intended to be highly selective, and are tuned to the i-f by means of the adjustable iron cores, of which there is one for each i-f coil. In Experiment No. 5, it was observed that the i-f cores had fairly critical settings for maximum output. Over a period of time the transformers may become detuned, decreasing the selectivity and sensitivity. Some of the difficulties which may be traced to misalignment are: reception of unwanted signals, difficulty in finding the desired signal and separating it from others, decrease in signal-to-noise ratio, etc.

When it is found necessary to align the i-f transformers, due to encountering some of the difficulties mentioned above, the following general procedure should be used. The 3rd i-f transformer is aligned first. A 915-kc. signal from a signal generator is introduced into the preceding stage (at the control grid of the tube), and the screws which move the iron cores in and out of the coils are varied. (Figure 7 shows the locations of these screws.) This varies the inductance in the circuits concerned, and tunes them. The two coils of the transformer are adjusted together, since the tuning of one circuit will affect that of the other. The proper setting for the screws is determined by the maximum output which can be obtained. Headphones can be used to indicate maximum output, but an output meter is much more dependable. After the 3rd i-f transformer is properly aligned, the 2nd and 1st i-f transformers are aligned in the same way.

The signal generator used in alignment should have a control to vary the output in microvolts. This control is useful in determining whether various stages of the receiver have proper sensitivity. For example, a signal of 60,000 microvolts introduced at the grid of the 3rd i-f amplifier tube should give an audio output of 10 milliwatts if the set is operating properly. Thus, it is possible to connect a meter across the receiver output (terminals 1 and 5 on the connector plug may be used) to measure the output in milliwatts, rather than relying only on maximum audio output in the headphones.

A rectifier-type voltmeter giving r-m-s readings and having a constant impedance across the output posts can be used to measure power output. Since it will be necessary to determine only the standard output of 10 milliwatts as the microvolt input to various stages is varied, and since the impedance of the meter is known, only one voltage reading equivalent to 10 milliwatts need be computed. For example, the output meter contained in Test Set I-56-A may be used; it is a rectifier type voltmeter with a constant impedance of 4000 ohms. On this meter, a voltage reading of 6.3 volts is the equivalent of 10 milliwatts. Therefore, if this voltmeter reads 6.3 volts when signals of the proper voltages are applied at various points in the receiver (which can be determined from the alignment chart in the experiment), it will be known that the receiver is properly aligned, and that all of the components in the receiver are operating as designed.

TUNING-DIAL CALIBRATION

The TUNING control on the front panel is mechanically coupled to the tuning dial and to the ganged tuning capacitors by means of a shaft and a number of gears. This arrangement is intended to rotate the dial as the ganged tuning capacitors are varied so that the indicator line will show the exact frequency, on the dial scale, to which the receiver is tuned. Over a period of time the dial may be moved away from the point of proper calibration due to hard usage, excessive pressure on the TUNING control at the ends of the bands, etc. Poor calibration will become apparent to the operator when he tunes to a signal of known frequency (such as a signal from a calibrated signal generator) and finds the dial-scale reading to be incorrect, when it is known that the receiver circuits are properly aligned.

The relationship between the dial and the tuning capacitors may be adjusted so that the dial can be correctly calibrated. It is desirable that this be done prior to aligning the r-f, 1st-detector, and heterodyne-oscillator stages. On the underside of the chassis, two setscrews will be found in pinion-gear-and-bushing assembly 268, which is geared to the large split gear on the ganged-tuning-capacitor shaft (see figure 18). When these setscrews are loosened, the tuning capacitor is disengaged from the TUNING control and the dial. The tuning-capacitor shield must be removed and the capacitors completely closed (rotor plates meshed with stator plates). At the low-frequency end of the dial scale for band 6 (13.5-18 mc.) there is an isolated calibration mark; the TUNING control should be varied until this mark is aligned with the indicator line on the index plate. The dial is now calibrated, since the receiver is so designed that the tuning capacitor should be fully closed when the frequency indicator is directly in line with the calibration mark on the

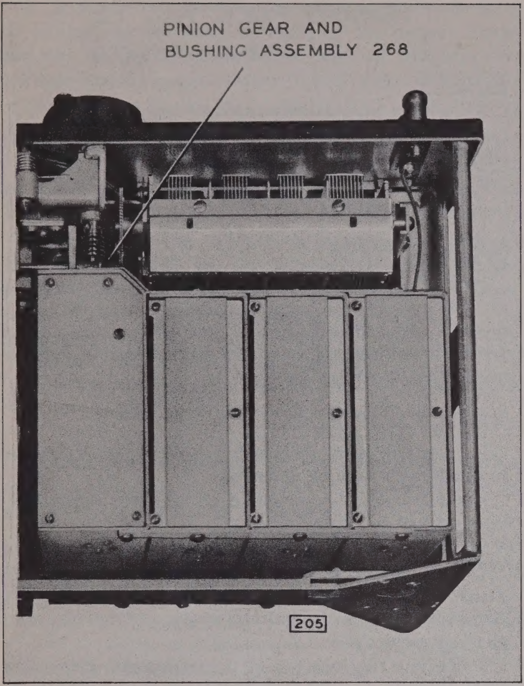


Figure 18. Location of Pinion-Gear and-Bushing Assembly 268

dial. The final step is to tighten the setscrews, thus re-engaging the tuning capacitor with the TUNING control.

ALIGNMENT OF THE 1ST AND 2ND R-F, 1ST-DETECTOR, AND HETERODYNE-OSCILLATOR STAGES

Trimmer capacitors make possible the adjustment of the tuned circuits in the first four stages of the receiver so that the 1st and 2nd r-f and the 1st-detector stages can be tuned simultaneously, by means of the TUNING control, to the same frequency, and so that the frequency difference between these stages and the heterodyne oscillator is constant (915 kc) at all settings of the TUNING control. When this is achieved, these circuits are said to track.

Like the i-f transformers, the tuned circuits in the 1st and 2nd r-f, 1st-detector, and heterodyne-oscillator stages may become detuned over a period of time, resulting in a decrease in selectivity and sensitivity. In aligning these stages, the general method is to align one band at a time. An r-f signal generator is used to apply a signal of known frequency between the antenna post and ground, and the tuning dial is set to the same frequency, which is selected to be near the high end of the band. By varying the four trimmer-capacitor screws associated with the particular band being aligned, the circuits for that band can be tuned to resonance (indicated by maximum audio output) so that all of the stages will be properly adjusted for that particular frequency. The design of the ganged tuning capacitors is such that the circuits will track satisfactorily over the rest of the band. As stated previously, however, the heterodyne-oscillator circuit for the lowest band (200-500 kc.) is equipped with two trimmers, the second one being necessary to achieve good tracking at the lower end of the band. Thus, for band 1, the heterodyne-oscillator stage must be aligned at both the high end and the low end of the band. It should be remembered that, in aligning the first four stages, the circuits in the r-f and 1st-detector stages are tuned to the signal-generator frequency. The heterodyne-oscillator circuit, however, is tuned to a frequency of 915 kc. away from the signal-generator frequency.

In aligning these stages, an output meter should be used to measure the audio output and receiver sensitivity as discussed in the alignment of the i-f stages. Alignment of only one stage, without alignment of the other stages in the receiver, should not be attempted, as it is generally ineffective. The entire alignment procedure and tuning-dial calibration, as discussed in this lecture and given in detail in the next experiment, should be followed, beginning with the 3rd i-f transformer and working back toward the r-f stages.

NEUTRALIZATION OF THE CRYSTAL-FILTER CIRCUIT

The coil and capacitor (150), which are used in connection with the crystal filter, determine whether unwanted signals which pass around the crystal due to the capacity of the crystal holder will be neutralized. By varying the capacitance of the filter-circuit, the circuit can be made to eliminate the unwanted signals.

All crystal-filter circuits are properly neutralized at the factory before the receivers are shipped; ordinarily, reneutralization is not required unless the neutralizing coil and capacitor or crystal (160) and switch assembly (167) have been replaced. However, if the crystal-circuit band-pass is found to be very broad, neutralization will be necessary.

The general method followed in neutralizing the crystal circuit involves the use of a signal generator and a microammeter to determine the crystal frequency. The microammeter is placed in the circuit between the 350,000-ohm section of resistor 110 and the cathode of VT-233, and the signal generator is connected between the signal grid of the 1st-detector, heterodyne-oscillator stage and ground. By varying the signal-generator frequency, a frequency will be found that gives a maximum indication on the microammeter. This frequency is the same as the crystal frequency. After the crystal frequency is determined, a signal 10 kc. lower is fed into the receiver and the neutralizing capacitor is tuned for a minimum microammeter reading. This low current reading indicates that signals more than a few thousand cycles away from the crystal frequency will not be effectively passed through the crystal-filter circuit.

The neutralizing capacitor consists of two wires extending from the neutralizing coil (see figure 19). The capacitor is tuned by bending the two wires (C

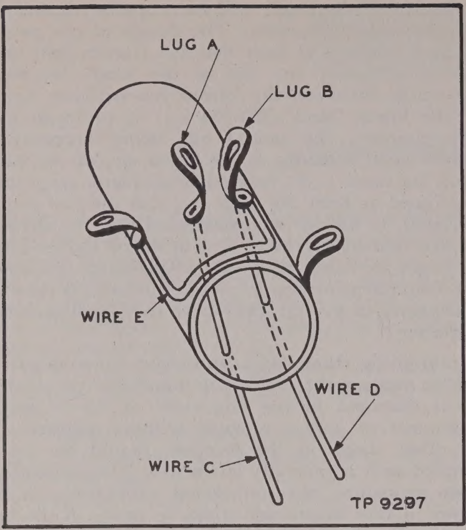


Figure 19. Neutralizing Coil and Capacitor (Crystal-Filter Circuit)

and D) closer together and farther apart, thus varying the capacitance between them. Extremely low capacitance can be secured, if necessary, by cutting off wires C and D, and also lugs A and B, to which the wires are connected. Wire E may also be moved away from lug A for lower capacitance.

ALIGNMENT OF THE C-W OSCILLATOR

The frequency of the c-w oscillator, which is used on c-w operation to produce an audible tone, can be varied by the BEAT FREQ. control on the front panel. The oscillator coil is located in a shielded unit on the underside of the chassis, and is attached to the back of the front panel, directly behind the BEAT FREQ. control. This control varies the inductance of the tank circuit (and thus varies its frequency) by moving an iron core in and out of the coil. The arrow on the BEAT FREQ. control knob is intended to be vertical and pointing upward at zero beat; that is, the frequency of the c-w oscillator should be 915 kc. in this position of the knob, with the result that a mixing of the c-w oscillator output and the incoming i-f signal (also 915 kc.) will result in no audio output or, at most, a very low tone.

Aging and replacement of components will sometimes alter the oscillator circuit so that zero beat occurs at some other position of the BEAT FREQ. control. When this happens, the relationship between the knob and the tuning core must be readjusted. The general procedure is to introduce a 915-kc. unmodulated signal into the receiver (at the signal grid of VT-150), find the zero-beat position of the BEAT FREQ. control, and loosen the two setscrews in the knob to disengage the knob from the shaft. The knob can then be turned so that the arrow is pointing straight up, without changing the position of the shaft. The screws are then tightened.

LESSON PLAN No. 12

TIME ALLOTTED: 1½ HR.

SUBJECT

Alignment and adjustment.

OBJECTIVE

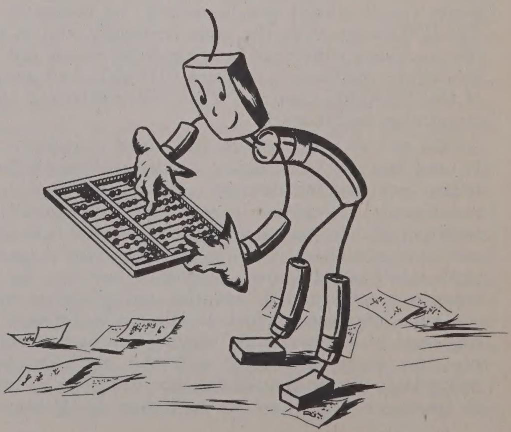
To familiarize the student with alignment and adjustment procedures.

INTRODUCTION

Certain circuits and components in Radio Receiver BC-348-J sometimes become misaligned and they must then be adjusted to bring the receiver back into alignment. Misalignment may be due to aging, replacement of parts, long usage, etc.

SUBJECT MATERIAL

1. Mention ways in which the need for alignment or adjustment may be detected.
2. Outline the five types of adjustments which may be necessary at sometime.
3. Review the functions of the i-f transformer cores.
4. Discuss the decrease in selectivity and sensitivity which occurs when the set is not properly aligned; mention common difficulties which can be traced to misalignment.
5. Review the location of the i-f-transformer adjustment screws.
6. Discuss the general procedure of aligning i-f transformers, emphasizing the following points:
    a. Use of a signal generator to inject a 915-kc. signal into the preceding stage.
    b. Adjustment of the core screws to vary the inductance of tuned circuits for maximum output.
    c. Interrelation of the core adjustments in the same transformer.
    d. Use of headphones and output meter.
7. Discuss how the signal generator can be varied to give a desired output in microvolts, and the usefulness of this feature in determining the sensitivity of various circuits.
8. Explain the use of the output meter to measure power output.



9. Explain how a rectifier-type voltmeter can be used to measure power output. Mention the output meter in Test Set I-56-A, and show how to compute the voltage reading equivalent to 10 milliwatts.

10. Explain the mechanical coupling of the TUNING control to the tuning dial and the ganged capacitors, and the reason for this arrangement.

11. Discuss the causes of mis-calibration of the tuning dial and how to detect it.

12. Point out the location of pinion-gear-and-bushing assembly 268 in the receiver and discuss the general procedure for calibrating the tuning dial, emphasizing the following points:

a. Loosen the setscrews in assembly 268.
b. Close the ganged tuning capacitors.
c. Align the indicator line on the index plate with the isolated calibration mark on the dial scale.
d. Tighten the setscrews.

13. Review the function of the trimmer capacitors and the location of the screws which adjust them; explain what is meant by "tracking."

14. Mention the decrease in selectivity and sensitivity resulting from misalignment of the r-f, 1st-detector, and heterodyne-oscillator stages.

15. Discuss the general procedure of aligning the r-f, 1st-detector, and heterodyne-oscillator stages, emphasizing the following points:

a. Alignment of one band at a time.
b. Use of a signal generator to apply an r-f signal at the antenna post.
c. Selection of a known frequency near the high end of the band.
d. Adjustment of the trimmer capacitor screws in all four circuits (one in each stage) associated with the particular band, for maximum output.
e. All bands are aligned in the same way except the lowest where adjustments at the low and high ends of the band are necessary.
f. R-f and 1st-detector stages are tuned to the generator frequency, but the heterodyne-oscillator is tuned 915 kc. away from the generator frequency.

16. Mention the use of the output meter, and the need for carrying out the complete alignment procedure.

17. Review the function of the neutralizing coil and capacitor; mention that the capacitor determines the neutralizing action of the crystal-filter circuit.

18. Discuss the conditions which may necessitate neutralization.

19. Discuss the general procedure for neutralizing the crystal circuit, emphasizing the following points:

a. Determine the crystal frequency by using a signal generator and microammeter.
b. Feed a signal 10 kc. lower than the crystal frequency into the receiver and tune the neutralizing capacitor for minimum current, which indicates a sufficiently narrow band-width.

20. Draw a picture of the neutralizing coil and capacitor (figure 19) on the blackboard.

21. Explain the manner in which the neutralizing capacitor is tuned.

22. Review the function of the BEAT FREQ. control; emphasize the manner in which it varies the frequency of the c-w oscillator.

23. Give the correct position of the arrow on the BEAT FREQ. control knob for zero beat; mention what the c-w oscillator frequency should be for this position of the control.

24. Discuss the causes of misalignment of the c-w oscillator, and explain how this condition can be detected.

25. Discuss the general procedure for adjusting the relationship between the BEAT FREQ. control knob and the tuning core, emphasizing the following points:

a. Introduce a 915-kc. signal into the receiver, and find the zero-beat position of the control.
b. Loosen the two setscrews in the knob, thus disengaging it from the shaft.
c. Rotate the knob so that the arrow is pointing straight up.
d. Tighten the setscrews.

CONCLUSIONS

In order to keep the receiver in its best operating condition, there is a total of five types of adjustments which can be made, when necessary. Only a few pieces of test equipment are needed to make these adjustments: an r-f signal generator, an output meter, and a microammeter.

ORAL QUIZ

1. Name the five types of alignment or adjustment which may be necessary in this receiver.

2. What is meant by "tracking?"

3. What signal-generator frequency is used in aligning an i-f transformer?

4. To what components is the TUNING control mechanically coupled?

5. Where would you connect the output of the signal generator to align the 2nd i-f transformer?

6. If the signal generator is tuned to 5.7 mc. (5700 kc.), in aligning the band-3 circuits, to what frequency should the heterodyne-oscillator circuit be tuned?

7. Can a voltmeter be used to check output power?

8. What is the purpose of the isolated calibration mark at the low-frequency end of the dial scale for band 6?

9. What is the effect on the neutralization of the crystal-filter circuit when the two wires extending from coil 150 are moved closer together and farther apart?

10. What component is moved when the BEAT FREQ. control is rotated? What is the effect of this movement on the circuit?

EXPERIMENT No. 9

TIME ALLOTTED: 3 HR.

SUBJECT

Alignment and adjustment.

OBJECTIVE

To become familiar with the methods used for the alignment and adjustment of the receiver.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J.
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-f signal generator (200 kc. to 18 mc.).
1 Output meter, rectifier type, 0—15 volts, 4000 ohms (contained in Test Set I-56-A and other Test Sets of the I-56 series).
1 Microammeter, 0—200 microamperes.
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet. Connect the output meter to terminals 1 and 5 of the connector plug; set the meter for the 15-volt range. Remove the shield from the ganged tuning capacitors (on the underside of the chassis) by loosening the two screws which fasten the shield to the chassis. Connect the signal-generator ground lead to the ground post of the receiver, using a short heavy lead. Connect the power source to the receiver. The receiver has been put out of alignment by the instructor. Assume that the receiver also requires the following adjustments: tuning-dial calibration, neutralization of the crystal circuit, and alignment of the c-w oscillator.

PROCEDURE

1. Set the receiver controls as follows:
a. C.W. OSC. switch to OFF.
b. CRYSTAL switch to OUT.
c. AVC-OFF-MVC switch to MVC.
d. INCREASE VOL. control to maximum.
e. BAND SWITCH to No. 2 Band (1.5—3.5 mc.).
f. TUNING control to 1.5 mc.

2. Turn on the signal generator and adjust it for a modulated signal. Using the I-F ALIGNMENT CHART (which follows), align the i-f transformers. Connect the signal-generator output to the points given in the chart through a .1-mf. capacitor. CAUTION! HIGH VOLTAGE! Turn the AVC-OFF-MVC switch to OFF when connecting or disconnecting the signal-generator output. Note that the signal-generator output connection for aligning the 1st i-f transformer is at the signal grid of VT-150. This grid is connected to an external terminal, which is at the front of the shielded OSC. unit and is available from the top of the chassis. Use this external terminal for the signal-generator connection; it is the second terminal from the top, in the right-hand row.

3. The sensitivity check prescribed for each i-f amplifier stage will indicate the accuracy of the alignment. If proper alignment of the stage does not produce the required sensitivity, trouble in the stage is indicated.

I - F ALIGNMENT CHART

STEP	SIGNAL GENERATOR		RECEIVER	
	CONNECTION TO RECEIVER	FREQUENCY SETTING	ADJUST	INSTRUCTIONS
1	Control grid (socket terminal 4) of 3rd i-f tube VT-116 through .1-mf. capacitor	915 kc. ± 1000 cycles	Tuning cores of 3rd i-f transformer	Set signal generator for about 1 volt input. Adjust top tuning-core screw (secondary) and then bottom tuning-core screw (primary) of 3rd i-f for maximum output. Repeat adjustments twice. Then make the sensitivity check. See Note A.
2	Control grid (socket terminal 4) of 2nd i-f tube VT-117 through .1-mf. capacitor	915 kc. ± 1000 cycles	Tuning cores of 2nd i-f transformer	Decrease signal-generator output until receiver output is about 10 milliwatts. Adjust top tuning-core screw and then bottom tuning-core screw of 2nd i-f for maximum output, decreasing the signal-generator output, if necessary, to maintain a receiver output of about 10 milliwatts. Repeat adjustments twice. Then make the sensitivity check. See Note A.
3	Signal grid (external terminal) of 1st-detector, heterodyne-oscillator tube VT-150	915 kc. ± 1000 cycles	Tuning cores of 1st i-f transformer	Decrease signal-generator output until receiver output is about 10 milliwatts. Adjust top tuning-core screw and then bottom tuning-core screw of 1st i-f for maximum output, decreasing the signal-generator output, if necessary, to maintain a receiver output of about 10 milliwatts. Repeat adjustments twice. Then make the sensitivity check. See Note A.

NOTE A: To check the sensitivity of the i-f amplifier stage, adjust the signal-generator output for a 10-milliwatt receiver output, and note the signal-generator output voltage. For normal i-f amplifier sensitivity, the signal-generator output voltage should be 60,000 microvolts for the 3rd i-f amplifier check, 2100 microvolts for the 2nd i-f amplifier check, and 35 microvolts for the 1st i-f amplifier check.

4. Disconnect the signal generator from the receiver and turn the AVC-OFF-MVC switch to OFF. Locate pinion-gear-and-bushing assembly 268 on the underside of the chassis, near the large split gear on the ganged-tuning-capacitor shaft. Loosen the two setscrews in the bushing until the gear rotates freely on the shaft. The ganged tuning capacitors are now disengaged from the TUNING control and dial.

5. Set the BAND SWITCH for band 6 (13.5—18 mc.). Turn the TUNING control until the isolated calibration mark at the low-frequency end of the dial scale is aligned with the indicator line of the index plate. Push the ganged tuning capacitor completely closed; that is, until the rotor plates are completely meshed with the stator plates. These settings establish the proper relationship between the TUNING control, the tuning dial, and the ganged capacitors.

6. Tighten the setscrews in the pinion-gear-and-bushing assembly carefully, in order to avoid changing the position of the tuning capacitors. The tuning capacitors are thus recoupled with the TUNING control and dial. Replace the tuning-capacitor shield.

7. Set the receiver controls as follows:

a. C.W. OSC. switch to OFF.
b. CRYSTAL switch to OUT.
c. AVC-OFF-MVC switch to MVC.
d. INCREASE VOL. control to maximum.

8. Connect the signal-generator output to the receiver antenna post, using the 100-mmf. capacitor. Turn the AVC-OFF-MVC switch to MVC. Adjust the signal-generator output for a 10-milliwatt reading on the output meter. Using the r-f, 1st-detector, and heterodyne-oscillator alignment chart (which follows), align the tuned circuits in these stages.

R - F, 1ST-DETECTOR, AND HETERODYNE-OSCILLATOR ALIGNMENT CHART

STEP	SIGNAL GENERATOR		RECEIVER			
	CONNECTION TO RECEIVER	FREQUENCY SETTING	BAND SWITCH	TUNING CONTROL	ADJUST	INSTRUCTIONS
1	To antenna post through 100-mmf. capacitor	470 kc.	Band No. 1 (200—500 kc.)	470 kc.	No. 1 trimmer on OSC., DET., R-F, and ANTENNA units	Adjust No. 1 trimmer on OSC. unit for maximum output. Then adjust No. 1 trimmer on DET., R-F, and ANTENNA units, in order, for maximum output. Repeat adjustments. Then make sensitivity check. See Note A.
2	Same as step 1.	Turn off signal generator. (See Note B.)	Same as step 1.	215 kc.	215-kc. oscillator padder	Adjust 215-kc. oscillator padder for maximum output. Repeat steps 1 and 2 two or three times to insure proper tracking. Then turn on signal generator and make sensitivity check. See Note A.
3	Same as step 1.	3.3 mc.	Band No. 2 (1.5—3.5 mc.)	3.3 mc.	No. 2 trimmer on OSC., DET., R-F, and ANTENNA units	Adjust No. 2 trimmer on OSC. unit for maximum output. Then adjust No. 2 trimmer on DET., R-F, and ANTENNA units, in order, for maximum output. Repeat adjustments. Then make sensitivity check. See Note A.
4	Same as step 1.	5.7 mc.	Band No. 3 (3.5—6 mc.)	5.7 mc.	No. 3 trimmer on OSC., DET., R-F, and ANTENNA units	Adjust No. 3 trimmer on OSC. unit for maximum output. Then adjust No. 3 trimmer on DET., R-F, and ANTENNA units, in order, for maximum output. Repeat adjustments. Then make sensitivity check. See Note A.
5	Same as step 1.	9.0 mc.	Band No. 4 (6.0—9.5 mc.)	9.0 mc.	No. 4 trimmer on OSC., DET., R-F, and ANTENNA units	Adjust No. 4 trimmer on OSC. unit for maximum output. Then adjust No. 4 trimmer on DET., R-F, and ANTENNA units, in order, for maximum output. Repeat adjustments. Then make sensitivity check. See Note A.
6	Same as step 1.	13.0 mc.	Band No. 5 (9.5—13.5 mc.)	13.0 mc.	No. 5 trimmer on OSC., DET., R-F, and ANTENNA units	Adjust No. 5 trimmer on OSC. unit for maximum output. Then adjust No. 5 trimmer on DET., R-F, and ANTENNA units, in order, for maximum output. Repeat adjustments. Then make sensitivity check. See Note A.

R - F, 1ST-DETECTOR, AND HETERODYNE-OSCILLATOR ALIGNMENT CHART (Cont.)

STEP	SIGNAL GENERATOR		RECEIVER			
	CONNECTION TO RECEIVER	FREQUENCY SETTING	BAND SWITCH	TUNING CONTROL	ADJUST	INSTRUCTIONS
7	Same as step 1.	17.3 mc.	Band No. 6 (13.5—18.0 mc.)	17.3 mc.	No. 6 trimmer on OSC., DET., R-F, and ANTENNA units	Adjust No. 6 trimmer on OSC. unit for maximum output. Then adjust No. 6 trimmer on DET., R-F, and ANTENNA units, in order, for maximum output. Repeat adjustments. Then make sensitivity check. See Note A.

NOTE A: To check the receiver sensitivity, adjust the signal-generator output until the receiver output meter reads 10 milliwatts. Turn off the modulation of the signal generator. Then adjust the receiver INCREASE VOL. control until 0.3 milliwatt (1.1 volts) of noise output is indicated on the output meter. Turn on the generator modulation again, and increase the output to obtain 10 milliwatts on the output meter. For normal receiver sensitivity the generator output should be approximately 9 microvolts.

NOTE B: For this adjustment, the noise developed by the receiver is used as the signal.

9. To neutralize the crystal-filter circuit use the following procedure: Connect the signal-generator output to the signal grid of VT-150 (same external terminal used in aligning the 1st i-f transformer) through a .1-mf. capacitor; connect the ground lead to the receiver ground post. Place the microammeter in series with the lead from the rear section of the volume control (the 350,000-ohm section of resistor 110) to the 2nd-detector cathode; this can be done by locating resistor 110 on the underside of the chassis, directly behind the INCREASE VOL. control, and unsoldering the red-blue lead at the volume-control lug. Connect the red-blue lead to the positive terminal of the microammeter, and the volume control lug to the negative terminal of the microammeter.

Connect the 28-volt power supply to the receiver. Set the receiver controls as follows: C.W. OSC. switch to OFF, CRYSTAL switch to IN, AVC-OFF-MVC switch to MVC, INCREASE VOL. control to maximum, BAND SWITCH and TUNING control for 1.5 mc. Allow the receiver and signal generator to warm up for several minutes.

10. Adjust the signal generator for a modulated 915-kc. signal of about 30 microvolts. Rotate the generator tuning control slightly until the crystal peak is located, as indicated by a maximum reading on the microammeter. Tune carefully to the exact peak and note the frequency of the generator. This frequency will be the frequency of the crystal, and should not be more than 1.3 kc. above or below 915 kc. Ordinarily, if the frequency is not within these limits, the crystal should be replaced.

11. Retune the signal generator 10 kc. below the measured crystal frequency. For example, if the crystal frequency is 916.2 kc., tune the signal generator to 906.2 kc. Turn off the signal-generator modulation and increase the output to about 1 volt. Locate wires C and D extending from the neutralizing coil (150) on the underside of the chassis. The capacitance between these two wires serves as the neutralizing capacitor. Vary the capacitance between wires C and D, by bending them closer to each other and farther apart, until the microammeter reading is at a minimum. When the capacitance of the two wires is properly adjusted, the signal passed by the capacitance of the crystal holder is neutralized, and thus prevented from passing to the 2nd-detector circuit. Turn off the receiver, remove the microammeter, and solder the connection to the proper volume-control lug.

11. To align the c-w oscillator, leave the signal generator connected as it is, and adjust it for a 30-microvolt unmodulated output at 915 kc. Plug headphones into the TEL. JACK. Turn the C.W. OSC. switch to ON, and the AVC-OFF-MVC switch to MVC. Rotate the BEAT FREQ. control to the zero-beat position, which can be determined by listening to the audio output in the headphones (at zero beat there will be no sound or, at most, a very low-pitched hum.) The arrow on the BEAT FREQ. knob should be pointing straight up. If it is not, loosen the two setscrews in the knob (which fasten the knob to the shaft) and rotate the knob so that the arrow is pointing correctly. Tighten the knob, making sure that the shaft does not move from the zero-beat position.

12. Restore the receiver to its original condition.

CONCLUSIONS

1. Why must band 1 be aligned twice?
2. Would the crystal have any effect on the alignment procedure if it were switched into the circuit?
3. Why is a much larger signal required to align the 3rd i-f transformer than the 1st i-f transformer?
4. What is the reason for repeating the adjustment of the i-f cores several times?
5. To what components is the pinion-gear-and-bushing assembly 268 geared?
6. In the tuning-dial calibration, why is it correct procedure to close the ganged tuning capacitors when the isolated calibration mark is lined up with the indicator line on the index plate?
7. Why must care be exercised in tightening the setscrews in the pinion-gear-and-bushing assembly 268?
8. What does the microammeter measure in the crystal-filter circuit neutralizing adjustment? Why is maximum indication obtained when the signal generator is tuned to the crystal frequency?
9. Why is it important that the crystal frequency be very close to 915 kc.?
10. What would be the effect on the crystal-filter circuit if the two wires extending from the neutralizing coil were cut off?

THE PHILCO TROUBLE-SHOOTING PROCEDURE

The Philco trouble-shooting procedure is logical, thorough, and easy to follow. It is based upon:

First—Localization of the trouble to a functional section, or block of circuits.

Second—Isolation of the faulty circuit within that section.

Third—Location of the defective part within that circuit.

In the Philco procedure, localization of the trouble to a functional section is accomplished, if possible, by an operational check, which is in chart form for convenience. By means of this check, the serviceman often can localize the trouble to a block of circuits immediately, without needless testing.

If the trouble cannot be localized by the operational check, it should be localized by a step-by-step trouble-shooting procedure, which is also in chart form. Each sectional chart refers to one or more major test points, 1, 2, etc.; a group of key test points, A, B, etc.; and if required, a group of secondary test points, A1, A2, etc.; all test points are indicated on the schematic diagram and photographs. Tests at the major test points throughout the equipment will definitely localize the trouble to a particular section, and eliminate other sections from suspicion.

After the trouble has been localized to a section, either by the operational check or by tests at major test points, additional tests at the key and secondary test points, specified in the chart, will isolate the faulty circuit. The defective part can be located by testing tubes, by further voltage and resistance measurements, or by substitution of parts.

LECTURE No. 13

TROUBLE-SHOOTING

When a trouble is found to exist in the equipment, a careful visual inspection is made first. Such apparent trouble indications as loose or broken wires, cables, and terminals, or evidence of physical damage to components are noted and corrected.

Secondly, if visual inspection does not reveal the cause of trouble, the operational check given in the Philco Trouble-Shooting Manual on Radio Receiver BC-348-J, BC-348-N, or BC-348-Q (published by Philco Corporation in 1947) is made.

Finally, if performance of the operational check does not clear the trouble, the step-by-step trouble-shooting procedure given in the manual referred to above is used.

LESSON PLAN No. 13

TIME ALLOTTED: 1½ HR.

SUBJECT

Trouble-shooting.

OBJECTIVE

To familiarize the student with the over-all method of trouble-shooting Radio Receiver BC-348-J.

INTRODUCTION

In previous experiments, trouble-shooting procedures involving the use of designated test points and voltage and resistance measurements were given for locating trouble in individual circuits. In this lesson, the complete procedure for locating troubles anywhere in the receiver will be discussed.

SUBJECT MATERIAL

1. State the value of making a preliminary search for trouble by means of a visual inspection.
2. Referring to the Philco Trouble-Shooting Manual on Radio Receiver BC-348-J, BC-348-N, or BC-348-Q, state the steps of the operational check, one at a time, and explain their objectives. Make use of the blackboard and wall charts, as required.
3. Referring to the same manual, state the steps of the trouble-shooting procedure, one at a time, and explain their objectives. Make use of the blackboard and wall charts, as required.

CONCLUSIONS

A trouble in Radio Receiver BC-348-J can be located by the use of the systematic procedure outlined in this lesson, which includes the use of visual inspection, operational check, test points, and voltage and resistance measurements.

ORAL QUIZ

1. Does the trouble-shooting procedure which has been discussed in this lesson deal with physical units?
2. How many major test points are there? What are they used for?
3. What do the key test points check?
4. If a secondary test point isolated the trouble to the 1st i-f stage, what would be the next step in locating the defect?
5. What is the value of visual inspection in the trouble-shooting procedure?

EXPERIMENT No. 10

TIME ALLOTTED: 2 HR.

SUBJECT

Trouble-shooting.

OBJECTIVE

To become familiar with the over-all method of localizing, isolating, and locating troubles in Radio Receiver BC-348-J.

EQUIPMENT REQUIRED

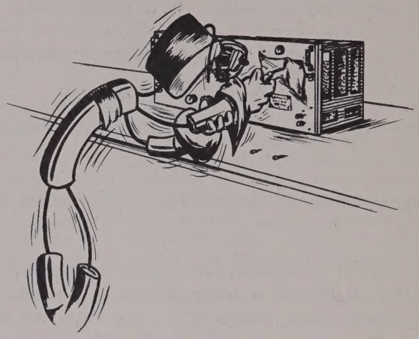
1 Radio Receiver BC-348-J.
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 R-f signal generator (200 kc. to 18 mc.).
1 A-f signal generator.
1 D-c voltmeter with 100-volt and 500-volt ranges (20,000-ohms-per-volt meter preferred).
1 Ohmmeter.
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

Remove the receiver chassis from the cabinet, remove the small plate on the front panel, and connect the power source to the receiver.

PROCEDURE

1. Request the instructor to place a trouble in the equipment. By means of visual inspection, operational checks, tests at the test points, and further voltage and resistance measurements, as required, localize, isolate, and locate the trouble, and correct it. As soon as one trouble is corrected, have the instructor place another one in the equipment. Continue this procedure as long as time permits. At the conclusion of the experiment, restore the receiver to its original condition.



CONCLUSIONS

1. What is the normal indication at key test point Ⓓ ? Key test point Ⓔ ?

2. If the secondary coil of the 1st i-f transformer (147) is open, how many steps in the trouble-shooting procedure must be performed to locate this defect?

LECTURE No. 14

PREVENTIVE MAINTENANCE

In order to keep the receiver in its best operating condition, and to aid in preventing troubles from developing, a regular routine of inspection should be conducted. The following procedure is suggested:

DAILY INSPECTION

1. Turn on the receiver.
2. Check the dial lamps.
3. Check for proper operation on all bands, with the C.W.OSC. switch in the ON position. This test can be made by listening to the noise level of the receiver, in the headphones, with the INCREASE VOL. control at maximum.

100-HOUR INSPECTION

Make the following check, in addition to the checks listed under DAILY INSPECTION: Check the antenna, ground, and cable connections for effects of vibration.

500-HOUR INSPECTION

Make the following checks, in addition to the checks listed under 100-HOUR INSPECTION:

1. Check all dial lamps and vacuum tubes with Model 685 Tube Checker in Test Set I-56-A.
2. Inspect the dynamotor brushes, and replace if necessary.
3. Lubricate the dynamotor.
4. Lubricate the dial and tuning-capacitor drive mechanisms.
5. Check the dynamotor voltages.
6. Check the tube-socket voltages.

LESSON PLAN No. 14

TIME ALLOTTED: ¼ HR.

SUBJECT

Preventive maintenance.

OBJECTIVE

To familiarize the student with the preventive-maintenance procedure.

INTRODUCTION

Preventive-maintenance procedures have been set up and should be followed in order to keep the receiver in its best operating condition, and to aid in preventing troubles from developing.

SUBJECT MATERIAL

1. Discuss the need for preventive maintenance, and emphasize that it consists of a regular routine of inspection.

2. Discuss the general procedure for each of the following inspection periods:

a. Daily inspection.
b. 100-Hour inspection.
c. 500-Hour inspection.

CONCLUSIONS

A definite plan of periodic inspection will keep the receiver in good operating condition and will reduce the occurrence of troubles.

ORAL QUIZ

1. What is the maximum amount of time that should be allowed to elapse between operating checks of the receiver?

2. What checks should be made after the set has been operating for 100 hours?

3. What additional checks are made at 500-hour inspections?

4. Why should tubes be tested, even though the operational check indicates that the receiver is operating properly?

EXPERIMENT No. 11

TIME ALLOTTED: 1½ HR.

SUBJECT

Preventive maintenance.

OBJECTIVE

To become familiar with the preventive-maintenance procedure.

EQUIPMENT REQUIRED

1 Radio Receiver BC-348-J.
1 Plug PL-P103 or PL-Q103.
1 Set of cables.
1 Test Set I-56-A.
1 D-c voltmeter with 300-volt range (20,000-ohms-per-volt meter preferred).
1 Headphone.
28-volt d-c power source.

INSTRUCTIONS

This experiment will simulate, as much as possible, the procedure followed during a 500-hour check of the receiver. Remove the chassis from the cabinet, and connect the power source to the receiver.

PROCEDURE

1. Turn on the receiver, and check the dial lamps. Check for proper operation of the receiver, with the C.W. OSC. switch in the ON position, and the INCREASE VOL. control fully clockwise. Observe the noise level in the headphones on all bands. If this inspection were being made on an actual installation, this procedure would be performed at the location of the installation.

2. Check the antenna, ground, and cable connections for the effects of vibration. This check would also be performed at the location of the installation, but is not necessary at a bench inspection. All of the following checks will ordinarily be performed in the shop.

3. Using the Model 685 Tube Checker in Test Set I-56-A, or any other available tube checker, check all of the tubes for emission and other characteristics. Follow the procedure outlined in the test-set instruction book.

4. Turn off the receiver and disconnect the power source. Remove the dynamotor from the chassis, using the following procedure:

a. Loosen the five screws on the dynamotor strip, and withdraw the five leads, with the spade terminals, from under the screws. Retighten the screws partially so that they will clear the chassis when the dynamotor is removed.

b. Push the left (when viewed from the front of the chassis) thumbscrew-rod stop-spring toward the end plate with a screwdriver, and withdraw the thumbscrew rod until the second stop position is reached.

c. Loosen the four captive screws which fasten the dynamotor to the chassis, and lift the dynamotor vertically from the receiver.

5. Remove the dynamotor dust covers by removing the retaining screws. Find the four knurled caps covering the four dynamotor brushes. Remove the brushes and inspect them. Be careful not to get the brushes mixed. Replace them in their original positions. Notice the round retaining plates at both ends of the dynamotor. In a 500-hour inspection these retaining plates and the gaskets beneath them would be removed by removing the four screws holding each retaining

plate. The bearings would then be accessible for lubrication.

6. Replace the dynamotor dust covers and place the dynamotor back in the receiver, reversing the procedure outlined in paragraph 4.

7. Locate, on the underside of the chassis, the gear arrangement which is attached to the TUNING control. This mechanism would be lubricated in a 500-hour inspection.

8. Connect the power supply to the receiver. Check the voltages at the various terminals on the dynamotor terminal strip, using the procedures already learned in trouble-shooting. CAUTION! HIGH VOLTAGE! Use the 300-volt scale on the d-c voltmeter for the high-voltage readings.

9. Check the tube-socket voltages. If Model 665 Analyzer and the Model 666 Socket Selector of Test Set I-56-A are available, use them for making the voltage measurements, following the procedure on page 12 of the test-set instruction book. When making measurements on the 2nd r-f amplifier tube with the test set, the flexible lead on the orange adapter plug must be removed from the pin jack marked GND and inserted in the outer No. 3 jack, because the shield is not grounded.

10. Restore the receiver to its original condition and repeat the operational check.

CONCLUSIONS

1. Can tubes be checked for proper operation without the use of a tube checker?

2. Is it necessary to have Test Set I-56-A if a 500-hour inspection of the receiver is being made?

3. How many leads are connected to the dynamotor terminal strip?

4. How can the dynamotor brushes be reached? The dynamotor bearings?

5. Why is it necessary to perform an operational check after testing and replacing the tubes?

LECTURE No. 15

SPECIAL INFORMATION

DIFFERENCES IN RADIO RECEIVERS

BC-348-J, BC-348-N, AND BC-348-Q

Radio Receivers BC-348-J and BC-348-N are identical in all respects. Radio Receiver BC-348-N, however, is intended to be part of SCR-287-A, which includes a transmitter; for that reason it was given a different letter, thus distinguishing it from the BC-348-J which, although an identical receiver, was not intended to be part of any specific system that includes a particular transmitter. Radio Receiver BC-348-Q is intended to be part of SCR-287-C, which includes a transmitter; it differs from the other two receivers in that resistor 104 (750 ohms) is not used as a shunt across the cathode winding of heterodyne-oscillator coil 143, which is utilized for band 6 operation. In addition, the reference symbols of certain trimmer capacitors in Radio Receiver BC-348-Q differ from those of the trimmer capacitors used in the other two types of receivers, although in all cases the capacitors themselves are exactly the same. The following list indicates the differences in symbols used for the three types of receivers:

FUNCTION	REFERENCE SYMBOL USED	
	BC-348-J and BC-348-N	BC-348-Q
2nd r-f trimmer, band 5	3-2A	2-7A
2nd r-f trimmer, band 6	3-2B	2-7B
1st-detector trimmer, band 1	3-3A	3-2A
1st-detector trimmer, band 2	3-3B	3-2B
Heterodyne-oscillator trimmer, band 1	3-4A	3-3A
Heterodyne-oscillator trimmer, band 2	3-4B	3-3B
Heterodyne-oscillator trimmer, band 3	3-5A	3-4A
Heterodyne-oscillator trimmer, band 4	3-5B	3-4B
Heterodyne-oscillator trimmer, band 5	3-6A	3-5A
Heterodyne-oscillator trimmer, band 6	3-6B	3-5B

MODIFICATION OF CERAMIC CAPACITORS IN RADIO RECEIVER BC-348-Q

The values of certain ceramic capacitors used in Radio Receiver BC-348-Q were changed during production. The list below indicates the parts affected and gives the original values and the new values. For replacement use, capacitors of the new and old values are directly interchangeable.

REFERENCE SYMBOL	ORIGINAL VALUE	NEW VALUE
32	138 mmf.	134 mmf.
33	110 mmf.	106 mmf.
40	74 mmf.	72 mmf.
43	62 mmf.	60 mmf.
48	22 mmf.	20 mmf.
49	20 mmf.	18 mmf.
50	20 mmf.	16 mmf.

MODIFICATION OF HEATER SHUNT RESISTOR

Heater shunt resistor 82 (190 ohms, 3 watts), in the tube filament circuit, has been replaced with two 390-ohm, 2-watt resistors connected in parallel (an equivalent of 195 ohms, 4 watts).

STATIC-DRAIN RESISTOR

Receivers stamped "M1" on the front panel have a one-megohm resistor (87-6) connected between the antenna post and ground. This resistor has been added to serve as a means of discharging static charges.

MOISTURE-FUNGUS PROOFED UNITS OF RADIO RECEIVER BC-348-Q

Radio Receivers BC-348-Q which are stamped "MFP" on the chassis are constructed of components which have been made moisture-fungus resistant.

OUTPUT CONNECTIONS

The audio output transformer (155-A) is provided with both high-impedance and low-impedance output terminals, making it possible to adapt the receiver for different types of headsets or loudspeakers. Receivers with the output circuits connected for low-impedance output are identified by a decalcomania, on the front panel, reading as follows:

NOTICE
Connected
for low
impedance
output

The center-tap (terminal 1) of the output transformer is the low-impedance connection and the end-tap (terminal 2) is the high-impedance connection. The output impedance may be changed easily by disconnecting the wire from one terminal and connecting it to the other terminal.

LESSON PLAN No. 15

TIME ALLOTTED: ½ HR.

SUBJECT

Special information.

OBJECTIVE

To familiarize the student with the variations and modifications in Radio Receivers BC-348-J, BC-348-N, and BC-348-Q.

INTRODUCTION

The information given in this course applies to Radio Receiver BC-348-J. However, with very few minor variations, it applies equally to Radio Receivers BC-348-N and BC-348-Q. In this lesson, these variations will be discussed; in addition, some recent modifications of these receivers will be considered.

SUBJECT MATERIAL

1. Explain the reason why Radio Receiver BC-348-N was given a different designating letter from BC-348-J (used in a system with a specific transmitter).
2. Explain the reason why Radio Receiver BC-348-Q was given a different designating letter (used in a system with a specific transmitter). Also review the fact that it does not use resistor 104 in the heterodyne-oscillator stage.
3. Discuss the differences in reference symbols for certain trimmer capacitors in Radio Receiver BC-348-Q, which are utilized even though the capacitors are the same as those used in the other two receivers.
4. Discuss the modification, during production, of certain ceramic capacitors used in Radio Receiver BC-348-Q.
5. Discuss the modification of heater shunt resistor 82, which has been replaced by two resistors.
6. Explain the addition of a static-drain resistor between the antenna post and ground in receivers stamped "M1" on the front panel.
7. Discuss the use of moisture-fungus proofed components in Radio Receivers BC-348-Q which are stamped "MFP" on the chassis.
8. Discuss the low-impedance and high-impedance connections on audio output transformer 155-A, and the use of a decalcomania notice on the front panel to identify receivers connected for low-impedance output.

CONCLUSIONS

Radio Receivers BC-348-J, BC-348-N, and BC-348-Q are essentially the same. Certain minor modifications in these receivers have been approved, and these modifications may be found in some of the equipment in actual installations.

ORAL QUIZ

1. In general, what are some of the differences between Radio Receivers BC-348-J and BC-348-Q?

2. Are the trimmer capacitors in Radio Receiver BC-348-Q, which have different reference numbers from those used in Radio Receiver BC-348-J, also different in value or construction?

3. Name one possible reason for replacing heater shunt resistor 82 with parallel resistors.

4. What does "M1" stamped on the front panel of a receiver indicate?

5. If a Radio Receiver BC-348-Q is stamped "MFP" on the chassis, what does it indicate?

6. How many kinds of output-impedance connections are available on audio transformer 155-A?

REVIEW No. 2

Display Wall Chart No. 2 and review the important points contained in Lectures No. 8 through No. 15, and Experiments No. 6 through No. 11, by orally interrogating the students. The normal time allotment for this review is four hours.

Beginning with Lesson Plan No. 8, state each question contained in the Oral Quiz section of each Lesson Plan and in the Conclusions section of each Experiment. Explain fully the answers to those questions which cause the students difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. Make a written note of each question on which the students indicate a general weakness.

FINAL REVIEW

Review those questions which have caused the students difficulty (refer to the written notations made during previous reviews). State each question and give a clear explanation of the answer. The normal time allotment for this review is two hours.

FINAL EXAMINATION

Do not permit the students to refer to any material while answering the questions in Part I of the examination. Display Wall Charts No. 1 and No. 2 before presenting Part II. The normal time allotment for these two parts is two hours total.

Part III of the examination should be conducted in the laboratory. Provide each student with the necessary equipment. Refer to the Trouble-Shooting Supplement for the placement of troubles in the equipment. Do not place a rigid time limit on this part of the examination, but rate each student according to the time required to locate and correct each trouble. The normal time allotment for this part of the examination is three hours.

PART I

1. Name the stages in which the gain of the tubes is controlled by the a-v-c voltage, in a-v-c operation.

2. What is the output frequency of the c-w oscillator at zero beat, when the receiver is properly aligned and tuned to the exact frequency of the incoming signal?

3. What is the frequency range of the heterodyne oscillator for band 2 operation (1.5—3.5mc.)? For band 6 operation (13.5—18.0 mc.)?

4. Is the crystal-filter neutralizing circuit in operation when the CRYSTAL switch is in the OUT position?

5. Name the circuit, in the 1st-detector stage, which prevents incoming signals having a frequency of 915 kc., from entering the 1st-detector, heterodyne-oscillator tube.

6. What component is adjusted when the crystal-filter circuit becomes unbalanced? Give a brief description of this component.

7. What is the voltage across the high-voltage output terminals of the dynamotor when the AVC-OFF-MVC switch is in the OFF position?

8. In what stages are the four sections of the ganged tuning capacitor electrically located?

9. What type of component is adjusted in aligning an i-f transformer? In aligning a tuned circuit in an r-f stage?

10. How is feedback secured for the heterodyne oscillator? For the c-w oscillator?

11. Why is it necessary to use a filter network in the a-v-c circuit?

12. How often should the dynamotor bearings be lubricated? How can these bearings be reached?

13. What is meant by the term "tracking?" By what means is it achieved?

14. What is the effect on the audio output when the BEAT FREQ. control is rotated, with the C.W. OSC. switch in the OFF position? In the ON position?

15. What is the purpose of the isolated calibration mark on the low-frequency end of the dial scale for band 6?

16. What is the primary function of the 2nd-detector stage?

17. Why is maximum audio output the proper indication for the correct setting of a trimmer capacitor when checking the alignment with a signal generator?

18. If this receiver is used in an installation with a transmitter, the transmitter relay will cut off the screen-grid voltage supply of three tubes when the

ORAL QUIZ

1. In general, what are some of the differences between Radio Receivers BC-348-J and BC-348-Q?

2. Are the trimmer capacitors in Radio Receiver BC-348-Q, which have different reference numbers from those used in Radio Receiver BC-348-J, also different in value or construction?

3. Name one possible reason for replacing heater shunt resistor 82 with parallel resistors.

4. What does "M1" stamped on the front panel of a receiver indicate?

5. If a Radio Receiver BC-348-Q is stamped "MFP" on the chassis, what does it indicate?

6. How many kinds of output-impedance connections are available on audio transformer 155-A?

REVIEW No. 2

Display Wall Chart No. 2 and review the important points contained in Lectures No. 8 through No. 15, and Experiments No. 6 through No. 11, by orally interrogating the students. The normal time allotment for this review is four hours.

Beginning with Lesson Plan No. 8, state each question contained in the Oral Quiz section of each Lesson Plan and in the Conclusions section of each Experiment. Explain fully the answers to those questions which cause the students difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. Make a written note of each question on which the students indicate a general weakness.

FINAL REVIEW

Review those questions which have caused the students difficulty (refer to the written notations made during previous reviews). State each question and give a clear explanation of the answer. The normal time allotment for this review is two hours.

FINAL EXAMINATION

Do not permit the students to refer to any material while answering the questions in Part I of the examination. Display Wall Charts No. 1 and No. 2 before presenting Part II. The normal time allotment for these two parts is two hours total.

Part III of the examination should be conducted in the laboratory. Provide each student with the necessary equipment. Refer to the Trouble-Shooting Supplement for the placement of troubles in the equipment. Do not place a rigid time limit on this part of the examination, but rate each student according to the time required to locate and correct each trouble. The normal time allotment for this part of the examination is three hours.

PART I

1. Name the stages in which the gain of the tubes is controlled by the a-v-c voltage, in a-v-c operation.

2. What is the output frequency of the c-w oscillator at zero beat, when the receiver is properly aligned and tuned to the exact frequency of the incoming signal?

3. What is the frequency range of the heterodyne oscillator for band 2 operation (1.5—3.5mc.)? For band 6 operation (13.5—18.0 mc.)?

4. Is the crystal-filter neutralizing circuit in operation when the CRYSTAL switch is in the OUT position?

5. Name the circuit, in the 1st-detector stage, which prevents incoming signals having a frequency of 915 kc., from entering the 1st-detector, heterodyne-oscillator tube.

6. What component is adjusted when the crystal-filter circuit becomes unbalanced? Give a brief description of this component.

7. What is the voltage across the high-voltage output terminals of the dynamotor when the AVC-OFF-MVC switch is in the OFF position?

8. In what stages are the four sections of the ganged tuning capacitor electrically located?

9. What type of component is adjusted in aligning an i-f transformer? In aligning a tuned circuit in an r-f stage?

10. How is feedback secured for the heterodyne oscillator? For the c-w oscillator?

11. Why is it necessary to use a filter network in the a-v-c circuit?

12. How often should the dynamotor bearings be lubricated? How can these bearings be reached?

13. What is meant by the term "tracking?" By what means is it achieved?

14. What is the effect on the audio output when the BEAT FREQ. control is rotated, with the C.W. OSC. switch in the OFF position? In the ON position?

15. What is the purpose of the isolated calibration mark on the low-frequency end of the dial scale for band 6?

16. What is the primary function of the 2nd-detector stage?

17. Why is maximum audio output the proper indication for the correct setting of a trimmer capacitor when checking the alignment with a signal generator?

18. If this receiver is used in an installation with a transmitter, the transmitter relay will cut off the screen-grid voltage supply of three tubes when the

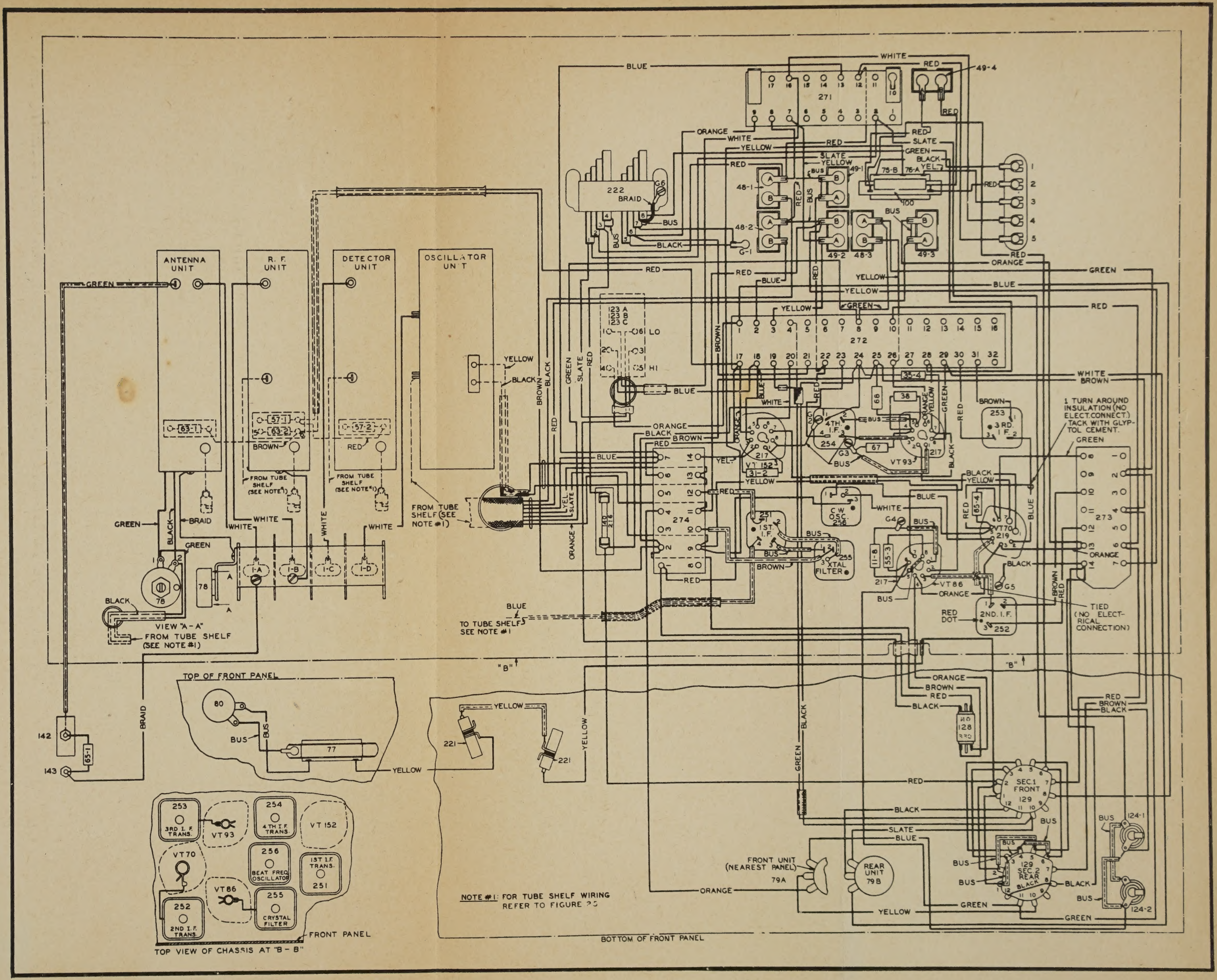
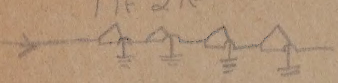
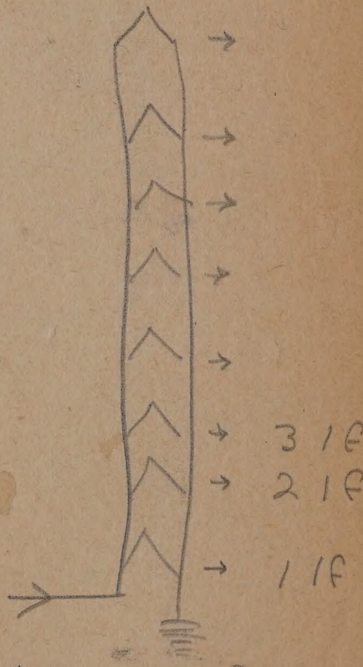

ANTENNA UNIT
R. F. UNIT
DETECTOR UNIT
OSCILLATOR UNIT
FROM TUBE SHELF (SEE NOTE #1)
VIEW "A-A"
TO TUBE SHELF SEE NOTE #1
TOP OF FRONT PANEL
BOTTOM OF FRONT PANEL
FRONT PANEL
TOP VIEW OF CHASSIS AT "B - B"
3RD I. F. TRANS.
4TH I.F. TRANS.
BEAT FREQ OSCILLATOR
1ST I.F. TRANS.
2ND I.F. TRANS.
CRYSTAL FILTER
VT 93
VT 152
VT 70
VT 86
1 TURN AROUND INSULATION (NO ELECT.CONNECT.) TACK WITH GLYP-TOL CEMENT.
TIED (NO ELECTRICAL CONNECTION)
FRONT UNIT (NEAREST PANEL) 79A
REAR UNIT 79B
SEC.1 FRONT 129
SEC.2 REAR 129
NOTE #1: FOR TUBE SHELF WIRING REFER TO FIGURE 25
271
272
273
274
222
142
143
"B"

Figure 8–17. Radio Receiver BC-348-(*) or BC-224-(*) —Wiring Diagram

omit 76A - i





transmitter is operating. In what stages are these tubes located?

19. Name the stages in which the gain is controlled by the INCREASE VOL. control when the AVC-OFF-MVC switch is in the MVC position.

20. Which end of the band is used in aligning the band 6 circuits of the r-f, 1st-detector, and heterodyne-oscillator stages? In aligning the band 1 circuits?

PART II

1. The AVC-OFF-MVC switch is in the MVC position. What portion of the 350,000-ohm section of resistor 110 is in the circuit?

a. 175,000 ohms.
b. 350,000 ohms.
c. 20,000 ohms.
d. None.

2. The resistance reading between socket terminal 8 of the 3rd i-f amplifier tube and ground is 5 ohms. What is the probable cause of trouble?

a. Open resistor 103.
b. Shorted capacitor 15-1.
c. Open primary of transformer 149.
d. Shorted capacitor 61-5.

3. What is the probable cause of a zero d-c voltage reading between socket terminal 8 of the 1st i-f amplifier tube and ground?

a. Shorted capacitor 34.
b. Open resistor 101-2.
c. Open resistor 101-1.
d. Defective switch 168.

4. The contacts of the AVC-OFF-MVC switch do not make connection. What are the trouble symptoms?

a. Complete equipment failure.
b. Operation on MVC position, but not on AVC position.
c. Operation on AVC position, but not on MVC position.

5. Which functional block is probably at fault if the indication obtained when using major test point 2 is normal on voice reception but abnormal on c-w reception?

a. Heterodyne oscillator.
b. 1st r-f amplifier.
c. 2nd r-f amplifier.
d. C-w oscillator.

6. What is the probable cause of a zero resistance reading between socket terminal 4 of VT-233 and ground?

a. Shorted resistor 90.
b. Open capacitor 61-7.
c. Shorted resistor 86.
d. Shorted capacitor 27-1.

7. An abnormal indication is secured when using test point C. What is the next test point at which it would be logical to make a test?

a. D.
b. B.
c. C1.
d. 2.

8. What is the probable cause of a 28-volt d-c reading between socket terminal 2 of the 1st i-f tube and ground?

a. Shorted capacitor 63-1.
b. Open resistor 85.
c. Open resistor 87-4.
d. Shorted resistor 84.

9. What is the probable cause of a zero d-c voltage reading between socket terminal 6 of the 3rd i-f amplifier tube and ground?

a. Open capacitor 61-4.
b. Open resistor 92.
c. Shorted resistor 92.
d. Shorted resistor 103.

10. The contacts of switch 168 do not make connection. What are the trouble symptoms?

a. Complete equipment failure.
b. No voice reception.
c. No c-w reception.

PART III

The instructor will place six separate troubles in the equipment, one at a time. By means of visual inspection, operational check, check at test points, and voltage and resistance measurements, as required, localize, isolate, and locate each trouble and correct it. Restore the receiver to its original condition.

REVIEW OF FINAL EXAMINATION

State each question and trouble-shooting problem contained in the Final Examination. Fully explain the answers to those questions which cause the students difficulty. Permit the students to ask questions of their own. Allow classroom discussion on questions, within reasonable limits of time. The normal time allotment for this review is two hours.

WORLD WIDE

PHILCO
SERVICE

Printed in U.S.A.